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Editors: JOHN M. COULTER and CHARLES R. BARNES

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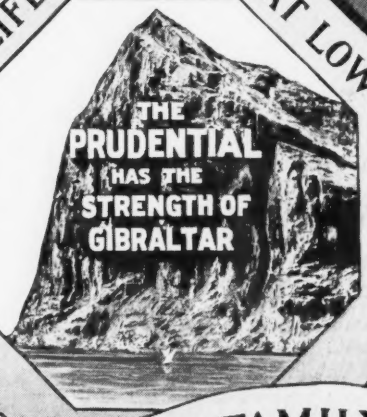

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VOLUME XXXIX NUMBER 1

BOTANICAL GAZETTE

JANUARY, 1905

THE EFFECT OF THE PRESENCE OF INSOLUBLE SUBSTANCES ON THE TOXIC ACTION OF POISONS.[1]

RODNEY H. TRUE and C. S. OGLEVEE.

IT has been repeatedly observed in connection with the poisonous action of dissolved substances that the harmful effects are much more marked when the roots of the plants under test are immersed in the solutions than when these are grown in sand cultures which are watered with like or even more concentrated solutions (**1**). Upon this point the practice advocated by NÄGELI (**2**) for removing traces of metals from distilled water may be cited. When to distilled water, rendered harmful for algae by the presence of traces of copper, crushed graphite, shredded filter paper, paraffin shavings, and other insoluble substances are added, the copper is removed from the water by some process dependent to a degree upon the amount of surface offered by the insoluble substance.

In connection with experiments carried out in 1902 by TRUE and GIES (**3**) at the Plant Physiological Laboratory at Woods Hole, Mass., on the modification of the action of poisons by the presence of other compounds, some preliminary experiments were made bearing on the effect exerted by the presence of insoluble materials on the behavior of seedlings of *Lupinus albus*. A concentration of copper sulfate was experimentally determined in which growth for twenty-four hours was possible, though at a somewhat diminished rate. When to duplicate cultures insoluble substances were added, in nearly all cases a marked increase in the growth rate was noted.

[1] After this paper was prepared, the line of argument and the evidence were submitted to Dr. LYMAN J. BRIGGS, physicist of the Bureau of Soils, U. S. Department of Agriculture. He has most generously given us the benefit of his special advantages.

The same volume of solution was used in each case and the same amount of copper was present in each culture. In some cases a copper-containing solution, in itself harmful, gave a marked stimulation when the insoluble material was added. In other cases the increase in the growth rate was less marked or, in two cases, absent. The general trend of the evidence, however, was clearly in favor of NÄGELI's conclusion that insoluble bodies in some way remove from action limited quantities of the copper in the solutions.

During the summer session of 1903, C. S. OGLEVEE, of the John Milliken University of Lincoln, Illinois, while working in the Plant Physiological Laboratory at Woods Hole, repeated the experiments above described and extended their scope. He used the radicles of seedlings of *Lupinus albus* as test objects.

The insoluble substances used represented several types of substances, having little in common beyond their insolubility. In making a choice of these the suggestions of NÄGELI were again acted upon. In experimenting with these different insoluble or difficultly soluble materials we attempted to use such quantities of each substance as would offer, as nearly as possible, like surfaces to the solutions. It is improbable, however, that even approximate accuracy was reached on account of the different sizes and shapes of the particles. Clean sea sand of rather coarse texture was used most frequently. It was selected from the cleanest parts of the beach near Woods Hole, boiled for about an hour in dilute hydrochloric acid, then thoroughly washed in fresh water and finally in distilled water.

Powdered Bohemian glass was prepared by crushing up some flasks and beakers that had been cracked or broken. This crushed glass was repeatedly washed in distilled water for a long time before being made use of in the experiment. It is a matter of common information that glass of this type is not strictly insoluble in water, and traces of the more soluble constituents were doubtless present in experiments with this substance.

Filter paper was also used. Cut filters of good commercial grade were shredded into distilled water and digested for a protracted period with several changes of water before use.

Powdered anthracite coal was also tried after a thorough treat-

ment with distilled water. It was noted that gas bubbles were repeatedly found over the surface of the submerged particles of coal and that after being removed by thorough stirring these would again form. This evolution of gas continued during the entire time in which the coal was under observation. The nature of the gas was not determined.

Finely divided pure paraffin of high melting point was also made use of. Investigations made on the effect of paraffin on the electrical conductivity of pure water have shown that paraffin does not noticeably increase the conductivity and seems to be practically insoluble in water.[2]

Owing to the lightness of the paraffin, the finely divided particles floated on the surface of the solutions, but owing to the small spaces between the pieces, the solution rose by capillary action among them and they became, in effect, submerged in the solutions.

At the suggestion of Dr. HENRY KRAEMER, of the Philadelphia College of Pharmacy, unruptured potato starch grains were tried. A stock was freshly prepared from potatoes by crushing and washing out the starch grains, care being taken to avoid other structures from the tuber. The starch thus obtained was dazzlingly white and distilled water in which a portion of the material was allowed to stand for some time gave no starch reaction when treated with iodine. By rubbing up a little of the same starch with a little distilled water a strong starch reaction appeared on adding iodine solution. Careful washing removed all traces of other substances.

The toxic substances receiving most attention in this investigation were those which have been shown to possess great poisonous activity. Copper sulfate, silver nitrate, mercuric chlorid, hydrochloric acid, sodium hydroxid, thymol, and resorcinol may be especially mentioned. The chemicals in the case of the heavy metals were Merck's guaranteed reagent grade. The remaining compounds were recognized makes of chemically pure quality. The solutions were made up with such care as the apparatus of the

[2] We are informed that investigations by F. K. CAMERON and LYMAN J. BRIGGS of the Bureau of Soils, U. S. Department of Agriculture, show that high grade paraffin of high melting point, of the sort here used, has but a minimal effect on the electrical conductivity of distilled water in which it is placed.

laboratory permitted, and we believe that the concentrations were usually accurate.

The method of operation consisted essentially in suspending the seedlings on glass rods in the solutions concerned for twenty-four hours each in each experiment, in such a manner as to immerse the radicles. In nearly all cases the plants were under observation at least forty-eight hours. Never less than four seedlings were used in any experiment and frequently more were employed. The average is taken as the result. The seedlings were placed with the roots in the solutions, care being taken to use plants in like stages of development. Growth was measured from an India ink line placed 15^{mm} from the tips of the roots at the beginning of the experiment. During the exposure to the action of the solutions the culture dishes stood in diffused light. The influence of variable factors, such as temperature, was kept track of by check cultures in distilled water.

The water was distilled in an apparatus lined with block tin and was not, therefore, of the highest purity. It was consistently used, however, throughout the season and forms a constant factor in all experiments. Beakers of 300^{cc} capacity and of similar shape were used.

In studying the effect of the presence of insoluble substances on the poisonous activity of the compounds mentioned, a quantity of the sand, filter paper, or paraffin was generally used equal to about one-third of the volume of the solution of the poisonous agent. Thus, in the beakers used for these cultures about two-thirds of the depth of the solution was to be seen *above* the level of the sediment in all but the floating paraffin, in which case the order was inverted.

After marking the roots and introducing them into the solutions under study, the plants were set away for twenty-four hours, at the end of which time they were again measured and the amount of growth noted. Usually, to avoid further complications arising in the case of prolonged experiments, the results due to exposure of twenty-four hours were sought.

EXPERIMENTAL RESULTS.

The first step taken with each toxic agent was to determine approximately the maximum concentration permitting the survival of the plants. This was then followed by a study of the results following the introduction of the particular insoluble substance under study.

The first group of toxic agents tested were exclusively electrolytes, which at the very advanced degree of dilution here seen may be regarded as acting chiefly as ions. The possible presence of a residuum of molecules, especially in the case of $HgCl_2$, is of no particular significance for the present discussion. Concentrations are always cited in terms of parts of a gram-molecule of the substance in question per liter of solution.

Mercuric chlorid.

Preliminary experiments were made to determine the toxic activity of the solution in the absence of insoluble substances. A concentration was then selected at which growth, although greatly depressed, is still possible before death results, and parallel cultures were then made in these concentrations both with and without the insoluble substance. The following table summarizes the results, growth made being indicated in millimeters:

TABLE I.

MERCURIC CHLORID.

1 gram-molecule	Growth in 24 hrs.	Growth in 70 hrs.
18,000 liters	2.0mm	6.5mm
18,000 + 75gm sand	6.0	21.0
20,000 liters	10.0	28.5
20,000 + crushed glass	16.9	40.0
Check in water	12.0	16.0

It is clear that the presence of both sand and crushed glass here modifies very markedly the toxic influence of the mercuric chlorid. This amelioration is evident not only during the first twenty-four hours of the experiment, during which the roots were exposed to the corrosive sublimate solution, but also during the following period of nearly two days, during which the roots were placed in tap water. The course of the check experiment shows that the presence of the insoluble bodies exerts a clearly stimulating effect on the roots. The same may be seen in a less marked degree in the more dilute solution lacking the insoluble substance.

Silver nitrate.

The above methods were applied to silver nitrate in a large number of dilutions, with somewhat less marked results.

TABLE II.

SILVER NITRATE.

1 gram-molecule	Growth in 24 hrs.	Growth in 48 hrs.
JULY 22		
150,000 liters	7.0mm	8.0mm
150,000 liters + sand	17.0	34.0
200,000 liters	13.0	22.0
200,000 liters + sand	16.0	31.0
200,000 liters + starch	13.0	22.0
250,000 liters	10.0	16.0 (weak seedlings.)
250,000 liters + sand	15.0	32.0
Water, distilled	16.0	19.0
Water + sand	12.0	14.9
AUGUST 20		
250,000 liters	16.0	
250,000 liters + sand	16.0	
300,000 liters	16.0	
300,000 liters + sand	18.0	
Distilled water	14.0	
Distilled water + sand	12.0	
AUGUST 17		
350,000 liters	14.0	
350,000 liters + sand	12.0	
350,000 liters + glass	14.0	
350,000 liters + filter paper	19.0	
Distilled water	12.0	
Distilled water + filter paper	13.0	
AUGUST 14		
350,000 liters	10.0	18.0
350,000 liters + sand	17.0	34.0
Distilled water	9.0	15.0

A study of the numerical data shows that in four cases out of ten, in which the active solutions with and without the solids are compared, no increased growth rate appears in the presence of the solid. In three out of four cases marked by the absence of an acceleration, the resulting growth rate agrees with that of the roots in the solutions lacking solids. In one case out of ten there is a retardation seen to follow the introduction of the solid. If we examine the six cases in which an acceleration followed the introduction of the solid, the sum of the differences in favor of the cultures containing the solids is 32^{mm}. Thus, seen collectively, the increase in growth rate due to the presence of the solids is very marked. Since no experiments were made for contrasting the efficiency of the various solids used, we cannot say in how far the differences in the nature or in the quantity of the

solids present may be responsible for the differences noted. In some degree, also, slight differences in handling during the experiment and also individual differences in the roots produce slight, uncontrolled effects.

Copper sulfate.

A greater number of experiments were made with copper sulfate than with any other substance. This has an added interest because of NÄGELI'S (**2**, p. 23) experiments with Spirogyra in extremely dilute solution. NÄGELI found that distilled water prepared by means of a copper still may contain enough metal to produce fatal results with Spirogyra. The remedy proposed as a laboratory expedient for making water thus prepared fit for use was to put finely divided insoluble bodies into the water. The results obtained with copper sulfate follow. Although there is considerable repetition and some experiments are not completely carried out, it seems desirable to present all the evidence, showing as it does the range of variation in the results:

TABLE III.

COPPER SULFATE.

1 gram-molecule	Growth in 24 hrs.	Growth in 70 hrs.
JULY 8		
32,768 liters	2.0mm	Dead
32,768 liters + glass	2.0	"
49,152 liters	3.0	"
49,152 liters + sand	4.0	"
Distilled water	12.0	17.0mm
JULY 10		
50,000 liters	1.0	Dead
50,000 liters + sand	14.0	28.0mm
65,000 liters	12.0	28.0
65,000 liters + sand	16.0	32.0
JULY 13		Growth in 48 hrs.
35,000 liters	1.0	Dead
35,000 liters + sand	7.0	12.0mm
40,000 liters	2.0	Dead
40,000 liters + sand	5.0	9.0mm
50,000 liters	2.0	Dead
50,000 liters + sand	11.0	17.0mm
Distilled water	10.0	13.0
Distilled water + sand	8.0	15.0

TABLE III—*Continued*

1 gram-molecule	Growth in 24 hrs.	Growth in 70 hrs.
JULY 16		
35,000 liters	4.0	Dead
35,000 liters + glass	10.0	17.0mm
35,000 liters + filter paper	18.0	32.0
Distilled water	12.0	15.0
Distilled water + glass	9.0	16.0
Distilled water + filter paper	12.0	21.0
Distilled water + glass wool	16.0	29.0
JULY 20		
35,000 liters + starch	12.0	
35,00 liters + glass wool	5.0	
Distilled water	14.0	
Distilled water + sand	12.0	
JULY 24		Growth in 72 hrs.
35,000 liters	3.0	
35,000 liters + paraffin	8.0	
Distilled water	12.0	
JULY 29		
35,000 liters	1.0	
35,000 liters + glass	4.0	
JULY 30		
35,000 liters	1.0	
35,000 liters + paraffin	3.0	
JULY 31		
35,000 liters	1.0	Dead
35,000 liters + garden soil	13.0	19.0mm
Distilled water	14.0	19.0
Redistilled water	15.0	16.0
AUGUST 5		
35,000 liters	2.0	
35,000 liters + sand	7.0	
35,000 liters + paraffin	5.0	
Distilled water	12.0	
AUGUST 10		Growth in 48 hrs.
35,000 liters	2.0	Dead
35,000 liters + 40grms sand	7.0	Living
35,000 liters + 80grms sand	10.0	Good condition
35,000 liters + 120grms sand	16.0	Excellent
35,000 liters + 160grms sand	13.0	Thrifty
35,000 liters + 200grms sand	12.0	Thrifty

Several facts seem to be clearly brought out in the above exhibit. Lupine roots are unable to survive an exposure of twenty-four hours to a concentration of copper sulfate in which a molecular weight is dissolved in much less than 60,000 liters—a point which has been

repeatedly observed before (**3, 4**). When, however, to a solution containing nearly or quite twice this amount of the copper salt, finely divided insoluble bodies, like quartz sand, crushed glass, and filter paper are added, the toxic action is so far diminished as to permit not only an increased growth before death takes place but even vigorous survival. In case the amount of copper is diminished, an advantage is regularly found in favor of the cultures containing the solid body.

In the case of the culture containing the garden earth, the effect of a common type of soil containing considerable soluble matter was desired. Of course chemical reactions have entered here, but at this great dilution the copper probably still existed in the ion condition. Here, too, the introduced soluble material may have had its own direct action on the organisms.

The action of paraffin is marked in every case but in a somewhat less degree than in the other cases noted. The paraffin offered some slight difficulty of method which may account somewhat for the fact observed. Although hard paraffin was used, it was found difficult to shave or chop it up into particles of the desired degree of minuteness. Thus less surface was exposed to the solution than in the other substances used. Its lightness, too, tended to buoy it up upon the surface of the solution, and prevent a thorough mingling. This was remedied in part by the tendency of the solution to rise by capillary action among the floating particles. It was also found practicable to hold the paraffin under, to a considerable degree, by means of pressure on the surface of the floating mass.

The effect of solids on growth in the distilled water was tried in control experiments, the general result seeming to indicate that the plants are not favored by this presence. Redistilling from glass, discarding the first half of the distillate and leaving a third of the original volume in the retort, seems to yield a product having no advantage over the water but once distilled.

In all of the toxic substances thus far considered, we have had to do exclusively with electrolytes, therefore, at the high dilutions concerned, with ions. Experiments were made with a few non-electrolytes in order to ascertain whether the ionization of the molecule may be a necessity for the observed decrease in the poisonous action of the presence of insoluble substances.

Non-electrolytes.

Those tested in this connection were phenol, resorcinol, and thymol. The investigations by BADER (**5**) on the conductivity of phenyllic compounds showed that in the substances here concerned no ionization is to be found. We have, therefore, here to do with entire molecules.

TABLE IV.

PHENOL.

1 gram-molecule	Growth in 24 hrs.
AUGUST 5	
200 liters	5.0mm
300 liters	6.5
300 liters + sand	6.0
Distilled water	11.5
AUGUST 7	
100 liters	1.0mm
100 liters + sand	2.0
150 liters	2.0
150 liters + sand	2.0
Distilled water	10.0

An inspection of the results shows no apparent amelioration resulting from the presence of the solid. It should be noted, however, in passing, that compared with the electrolytes used, phenol is a weakly toxic substance, and the plants are apt to make a good growth in solutions containing a comparatively great number of molecules (**9**).

TABLE V.

RESORCINOL.

1 gram-molecule	Growth in 24 hrs.
AUGUST 5	
200 liters	13.0mm
200 liters + sand	10.0
300 liters	10.0
400 liters	10.0
Distilled water	11.5
AUGUST 7	
100 liters	2.0
100 liters + sand	3.0
150 liters	3.0
150 liters + sand	5.0
Distilled water	10.0

In this substance, in concentrations great enough to interfere greatly with the growth rate, the presence of the solid seems to bring about a slightly increased rate of growth, this effect ceasing as the dilution is increased. Here we meet again a compound which is tolerated in considerable concentration by the plant (**9**).

TABLE VI.

THYMOL.

1 gram-molecule	Growth in 24 hrs.	Growth in 48 hrs.
JULY 30		
2600 liters	0.0mm	0.0mm dead
2800 liters	4.0	9.0mm; 2 dead
2800 liters + glass	14.0	28.0mm
JULY 31		
2600 liters	3.5	2 dead
2600 liters + sand	3.0	3 dead
AUGUST 5		
2600 liters	2.0	
2600 liters + sand	1.0	
2800 liters	4.0	
2800 liters + sand	5.0	
Distilled water	11.5	
AUGUST 7		
2600 liters	0.5	all killed
2600 liters + sand	2.0	all killed
2800 liters	0.5	all killed
2800 liters + sand	7.0	3 living
Distilled water	10.0	

The results with thymol, while not homogeneous, indicate that in a concentration of one mol. weight in 2600 liters of solution no steady advantage accompanies the presence of the solid. When the dilution is somewhat increased, however, such an advantage appears. The time at our disposal was too brief to carry out the study of this compound or others as far as seems desirable. Nevertheless, the preponderance of evidence seems to indicate in thymol, and less clearly in resorcinol, a favoring effect accompanying the presence of the solid (**9**).

DISCUSSION OF RESULTS.

The general situation developed by the results detailed above may with profit be summarized in order to furnish a clear view of the facts which are to underlie our further consideration.

It appears in general that the presence of a considerable body of certain insoluble substances in solutions of strongly toxic compounds, both organic and inorganic in their nature, be they electrolytes or not, tends to decrease the toxic activity of the solutions in question.

On the whole this ameliorating action is more clearly marked in case the poisonous solutions concerned are dilute solutions of strong poisons than when relatively concentrated solutions of weaker poisons are concerned.

In general, filter paper and potato starch grains exert a more marked modifying action than dense sand, glass, and paraffin.

A number of questions immediately arise concerning the relation in which the active ions or molecules stand to this phenomenon. It seems probable that no electrical phenomena are here necessarily concerned. In the case of electrolytes such a situation might be possible, but in thymol and resorcinol we have to do with electrically neutral bodies.

A more satisfactory explanation seems to lie in another quarter. Chemists have long known that gases form a denser layer over the surfaces of the walls of containing vessels than in the free space away from the walls. Certain solids have the capacity of condensing on their surfaces larger volumes of gases than others, seeming to have specific properties in this direction. For example, platinum in a finely divided form condenses many times its own volume of oxygen. A similar phenomenon has long been known in a practical way in the case of solutions. Many years ago it was noted that bone charcoal has the property of taking certain coloring bodies out of syrups, thereby clarifying the latter products. The investigation of this and similar phenomena has shown that molecules of many dissolved substances are attracted to the surface of charcoal, quartz, and filter paper, when these bodies are placed in these solutions, and in general the greater the state of subdivision to which these insoluble bodies are reduced, the more clearly may this condensation of molecules from the solution be seen. This process by which a layer of greater molecular density is formed on the surfaces of solids immersed in solutions has been denominated by DUBOIS-REYMOND *adsorption* (**6**).

Not all solids have been found to be equally effective as adsorbing

bodies and all molecules do not seem to lend themselves with equal readiness to the adsorbing influence of solids (**6**).

Applying this doctrine of adsorption to the results observed in our experiments, we find most points noted capable of explanation. The earlier experiments of NÄGELI (**2**) with Spirogyra in distilled water obtained from copper containers and in other solutions containing extremely minute quantities of heavy metals seem capable of satisfactory explanation. He observed that distilled water containing minute traces of metal could be rendered harmless by placing a quantity of some finely divided insoluble substance in the water. He used paraffin, graphite, filter paper, glass, and other substances, finding that they interfered with the toxic action of the metals present. Doubtless the quantity of harmful ions or molecules adsorbed was so great as to reduce the number of ions or molecules in the free body of the solution below the harmful concentration.

In the case of our lupines this same sort of action is also probably at the bottom of the ameliorating influence seen to attend the mere presence of a finely divided solid in solutions or strongly toxic agents. By drawing a portion of the ions or molecules of the poisonous substance from the free body of the solution and by retaining these molecules or ions in a molecularly denser layer over their surfaces, the solids have removed from the free solutions enough of the toxic substance to decrease its poisonous properties. Since in the case of all of the insoluble substances used, paraffin excepted, the specific gravity is greater than that of water, the solids sink to the bottom of the culture vessel. As adsorption takes place, a somewhat gradual process (**6**), molecules and ions are renewed from the solution above, leaving it actually less concentrated than would be the case were the solutions not provided with the solid. As a result, when the roots of the test plant are introduced into the solution, it is found to have a decreased poisonous action.

In the case of certain of the solids used in these experiments, it seems not at all impossible that a small degree of solution may have taken place. In experiments with crushed Bohemian glass this was doubtless the case, since it has been repeatedly demonstrated that such glass undergoes a slight solution even in cold water. Unfortunately we were not able to make conductivity determinations to check up this factor.

In the case of the starch grains, the potato tubers were crushed in a mortar, care being taken not to grind the material and crush the grains. The starch that settled out on washing was repeatedly washed with distilled water. Distilled water in which the starch grains were allowed to stand gave no trace of the starch reaction with iodine, a reaction which appears in case any considerable number of grains are crushed, exposing the more soluble interior layers. Some hesitation, however, may be felt as to the insolubility of the grains.

The question suggests itself as to whether all insoluble solids exert a like adsorptive action under these conditions (**6**). No attempt was here made to test this question, since it was not practicable under the conditions of experiment given to work with the accuracy necessary in such a study. Furthermore, since adsorption is dependent to a considerable degree on the amount of surface offered by the solid, some way of taking account of this factor would seem necessary. In the case of sand this could be done, but to carry over these values to filter paper and starch grains, consisting of masses of organic substance supposed by some (**7**) to have a submicroscopically porous structure, seemed to be impracticable. The lack, therefore, of any practicable unit, whether of weight or surface, by which to compare the solid substances used, made it best to content ourselves with a rough qualitative method.

In general, the most marked results seemed to follow when filter paper or starch grains were used. Whether this is due to the porous structure and consequently immensely enlarged surface, cannot here be discussed.

Another point of interest in this connection concerns the nature of the contact between the solution and the solid body. In all cases except that of paraffin the solution is capable of wetting the surface of the solid, thus bringing the molecules of solute and solvent into closest relation with the adsorbing surface. In the case of paraffin the situation is different. The solution is not capable of wetting the paraffin even when in as close contact as can be obtained. As a result, a surface of quite another sort is formed, more nearly comparable in some ways to that bounding the surface of the solution where it comes in contact with the air. At the point of contact

between the solution and the paraffin, the condition of the solution more nearly resembles the surface film. In this case this film surrounds the particles of submerged paraffin, and any properties found to be possessed by the surface of contact with the paraffin should be in a manner similar to those of surface films. However this may be, the surface of contact with the paraffin seems to be such as to bring about a condensation of molecules with a consequent removal of a portion of the poisonous substance from the free solution and a decrease of the poisonous properties of the solution. This happens, also, in the face of the fact that the paraffin floats and must condense the molecules in the upper part of the culture vessel. It might seem, therefore, that the surface portions of the solution should be markedly more toxic than the lower free portion. If this be so, the ions or molecules seem to be held so firmly by the adsorptive force that they are still in effect removed from the solution so far as the roots are concerned.

AMOUNTS OF TOXIC SUBSTANCE REMOVED FROM THE FREE SOLUTION BY ADSORPTION.

The results seen in the tables above given seem to show that solid bodies are capable of adsorbing molecules or ions of toxic compounds, holding them so closely that in effect they are removed from the solution. We see many cases in which the growth rate is so far accelerated by the presence of the adsorbing solid as to lead one to infer that a very considerable portion of the toxic agent may be adsorbed. In cases it is observed that reduction has so far taken place as to practically relieve the solution of its toxic properties. In some instances the solution, decidedly toxic without the solid, becomes capable of supporting a more than normal growth in the presence of the solid. Here, an abnormal acceleration replaces a marked retardation, judged from the growth rate made in the distilled water check culture. Such instances are seen in mercuric chlorid, $\frac{m}{20{,}000}$. A retardation is seen in the culture lacking the solid amounting to an average of 2 mm. When sand is added, the acceleration is so great as to bring the average growth rate in twenty-four hours to 16 mm, 4 mm more than in the control culture. In the case of silver nitrate a number of instances of this sort occur. In

case the solution without the solid permits a growth rate above that seen in the control, this increase is sometimes still further augmented by the presence of sand. The results with copper sulfate show a number of instances illustrating these different phases of action.

It is a well established fact of general physiology that many compounds which at certain concentrations act as harmful agents and depress activity become in more dilute solutions accelerators of activity. If dilution be carried on there arrives a point at which all effect ceases, and only the effect of the solvent appears. This has been pointed out by COUPIN (**8**) for certain salts. We may represent

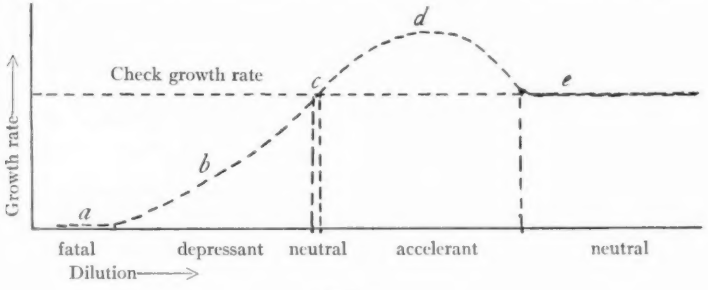

FIG. 1.

the different physiological phases resulting from the progressive dilution of a fatal concentration by a series of terms something like the following. Almost instant death (*a*) is followed by a lengthening period of survival (*b*) with depressed activity when compared with the control in water. This depressant phase is followed by a short phase in which the growth rate approximates the control (*c*). This passes over into the more extended acceleration phase (*d*) marked by activity beyond that seen in the control. This acceleration rises to a maximum and with further dilution falls off, until the solution becomes practically distilled water in its action on the organism (*e*). This may be represented diagrammatically as above (*fig. 1*), growth for the twenty-four hours in this case being indicated on the axis of ordinates, progressive dilution (that is, the degree of dilution) on the axis of abscissas progressing to the right, the growth of controls in distilled water being regarded as unaffected by other external conditions, and the roots used assumed to be in the same phase of

development. While it may not be practicable in all cases to work out all features of this generalized scheme with the very toxic salts tested, the most striking points hold.

It is now not difficult to understand a number of phenomena seen in results presented above. By preliminary tests not here detailed a concentration of each substance was found which practically suppressed growth and gave a physiological starting point from which to follow out the action of the poison along the line of progressive dilution and also in the presence of solids. In most cases, the solutions of the toxic compounds lie in the degree of concentration marked by a depressant phase of physiological action. As molecules or ions are removed by adsorption, the effect is virtually one of dilution, and the depressant action becomes less marked; or when adsorption removes a sufficient portion of molecules or ions to bring the solution into the accelerant phase, instead of the depressant, an acceleration above the control rate appears. The degree of acceleration depends on whether adsorption withdraws such a proportion of the molecules or ions as will leave the solution in its maximum accelerant phase or above or below this. It should also be borne in mind that at least theoretically, after the depressant phase has been passed, two quite differing concentrations lying on either side of the maximum may give the same physiological result. Experiments with solutions further diluted will enable one to decide on which side of the maximum the result may lie. Theoretically, a careful study of a long series of slightly differing concentrations should enable us to ascertain relatively how much of a given poison is removed by a given quantity of an adsorbing agent. This can hardly be attempted with justice from the results at hand, since they were obtained under conditions rendering the necessary accuracy of experimentation impossible. Nevertheless, I believe some rough idea may be obtained from the work presented. It will suffice to point out a few instances, since it is manifestly impossible to point out the application of this scheme to all of the results obtained.

In the case of the mercuric chlorid (p. 5) $\frac{m}{18{,}000}$ is manifestly low in the depressant phase of its action, the introduction of the sand carrying it a manifest step upward, though leaving the situation

still in the depressant phase. A solution $\frac{m}{20,000}$ permits a growth rate of 10^{mm}, still less than the control having a rate of 12^{mm}. The depressant phase of dilution is still represented, but is nevertheless but little below the neutral point.

The addition of an adsorbing body therefore should carry it into the accelerant phase. This is the result seen, and the growth of 16^{mm} compared with the check seems to represent a rate probably near the maximum. By making a series of experiments under conditions like those met in this experiment, in which a graded series of solutions of mercuric chlorid alone is used, we should be in possession of a calibrated standard by means of which we could estimate more or less accurately the amount of the toxic molecules adsorbed. Similar methods of interpretation applied to the results with silver nitrate indicate with varying degrees of clearness a similar situation.

The results obtained with copper sulfate illustrate many of the different phases of action. In some cases the presence of the solid served not only to clearly decrease the harmful action of the salt, but even to make survival possible in concentrations otherwise promptly fatal.

In this connection a series of experiments was made to ascertain approximately in how far the quantity of solid substance present might influence the action of a toxic concentration of a salt. For this purpose a series of six cultures was prepared with like quantities of copper sulfate. To five of them prepared sand was added in different quantities. The growth rates seen in Table III, August 10 (p. 7), have been plotted in the following diagram (*fig. 2*). The growth rate in millimeters is indicated as before on the axis of ordinates. The progressive addition of solids is shown on the axis of abscissas. Although, unfortunately, no control culture was made in this case, we may fairly accept 12^{mm} as average growth in distilled water on the date concerned. This value is plotted as the control result. The copper sulfate solution furnishing a basis for this experiment is concentrated enough to kill the roots promptly, usually permitting little growth. The addition of 40^{gm} of sand adsorbs a sufficient amount of copper sulfate to permit half the amount of growth expected of the control culture, and in addition to make possible the survival of the test objects. Nevertheless, a sufficient concentration is still present to leave the solution in the

depressant phase of concentration. The doubling of the amount of sand brings the growth rate nearly to the normal rate of the control, a slight depressant action still being seen. The roots, however, survive in good condition, so far as their appearance indicates. The increase of the sand to 120^{gm} results in so advanced a degree of adsorption that the growth rate is thrown clearly into the acceleration stage, perhaps near the maximum. Further additions still further reduce the molecules in the free solution and show a stage of dilution

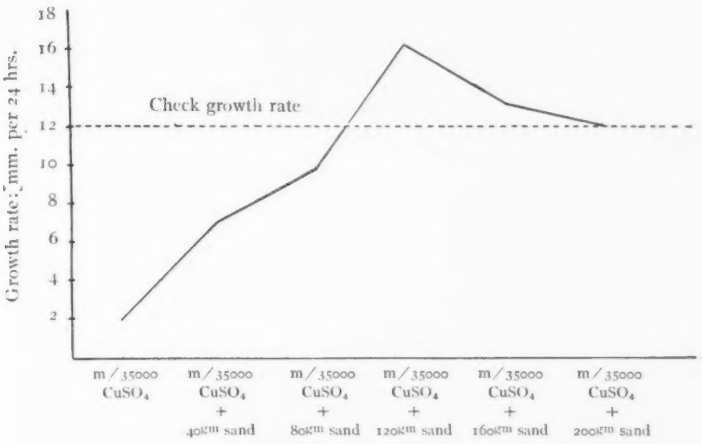

FIG. 2.

corresponding to the descending stimulus phase. The addition of 200^{gm} of sand shows this reduction of the copper effect at its limit. The free solution is, physiologically, distilled water, so far as the duration of the experiment allows one to judge. Here then the progressive addition of quantities of a solid produces results paralleling the progressive dilution of the toxic medium, the underlying cause of these results being the gradual removal of molecules or ions from the free solution by the insoluble body present.

In view of the evidence here presented and discussed, it is likely that the process recognized as adsorption plays an important rôle in many problems of plant and probably of animal physiology. Experiments by the water culture method cannot be used as a safe basis for argument concerning soil conditions. The so-called absorptive

properties of the soil toward chemical compounds which form a demonstration experiment in the usual elementary course in plant physiology is in considerable part a demonstration of adsorption. Indeed, the whole relation of the plant to its soil environment is very largely influenced by this factor.

It is also probable that in the internal processes of the plant and of the animal, similar forces are in operation, influencing, together with diffusion and osmosis, the movements and distribution of molecules and ions within the organism. For example, it would appear not at all improbable that in cells containing starch grains or other undissolved substances, the distribution of the various molecules and ions of the cell sap is to no insignificant degree influenced by adsorption, and the transfer of molecules or ions from place to place may be modified by this tendency of the walls, starch grains, and other porous but insoluble substances to attach to themselves condensed layers of molecules or ions. Indeed, it would be easy to see in a speculative way many directions in which the processes of life may be affected by the form of activity demonstrated in the above experiments to be in operation under certain common conditions.

In nature the roots themselves and other absorbing organs furnish surfaces for adsorption and the layer of solution about them is molecularly more dense than the free solution. This applies in a much greater degree to minute, submerged forms of life, as bacteria. Absorption into the cell takes place, therefore, in general from a denser layer at the surface of the organism by the continued operation of the energy of adsorption. This surface layer is continually renewed, resulting in an accelerated absorption.

Another relation of importance is seen in the size of the organism. The more minute, the greater would be the efficiency of adsorptive activity. This may aid in accounting for the extreme efficiency of the minuter forms of life in operating on their medium.

Many suggestions occur as to divers other ways in which adsorption may play a part more or less significant in the lives of living things, but to give them value the accumulation of more evidence is necessary. Further studies in this direction are in progress.

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THE RELATION OF SOILS TO NATURAL VEGETATION IN ROSCOMMON AND CRAWFORD COUNTIES, MICHIGAN.[1]

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY. LXVI.

BURTON EDWARD LIVINGSTON.

(WITH MAP)

IN a study[2] of the distribution of vegetation in Kent county, Michigan, made by the author several years ago, the tentative conclusion was reached that the controlling factor in the distribution of the plant societies on the upland is the amount of water in the soil, and that this in turn is determined by two conditions, the nearness of the underground water level to the surface and the water-retaining or capillary power of the surface layers. This last factor is dependent largely upon the size of the soil particles. It was thought well to continue this subject farther north, using the same methods. Accordingly in the summer of 1902 the work here reported was accomplished. It covers nearly all of Roscommon county and the southern half of Crawford county.

TOPOGRAPHY AND SOILS.

The region consists of a series of ridges and depressions. The former are sometimes several miles wide but more often narrow; they are always comparatively low, seldom rising more than 50 to 60 m above the level of Higgins Lake, which lies in the middle of the

[1] Published by permission of the U. S. Bureau of Forestry and of the Michigan Board of Geological Survey. A more detailed account of the investigations here recorded will appear in the Annual Report of the Michigan State Geologist, 1903. The map here presented is from the last-named report. A very brief statement of the conditions in this region has been published in the Report of the Michigan Forestry Commission, 1902.

[2] LIVINGSTON, B. E., The distribution of the plant societies of Kent county, Michigan, Ann. Report Mich. State Board Geol. Survey **1901**: 81–103.

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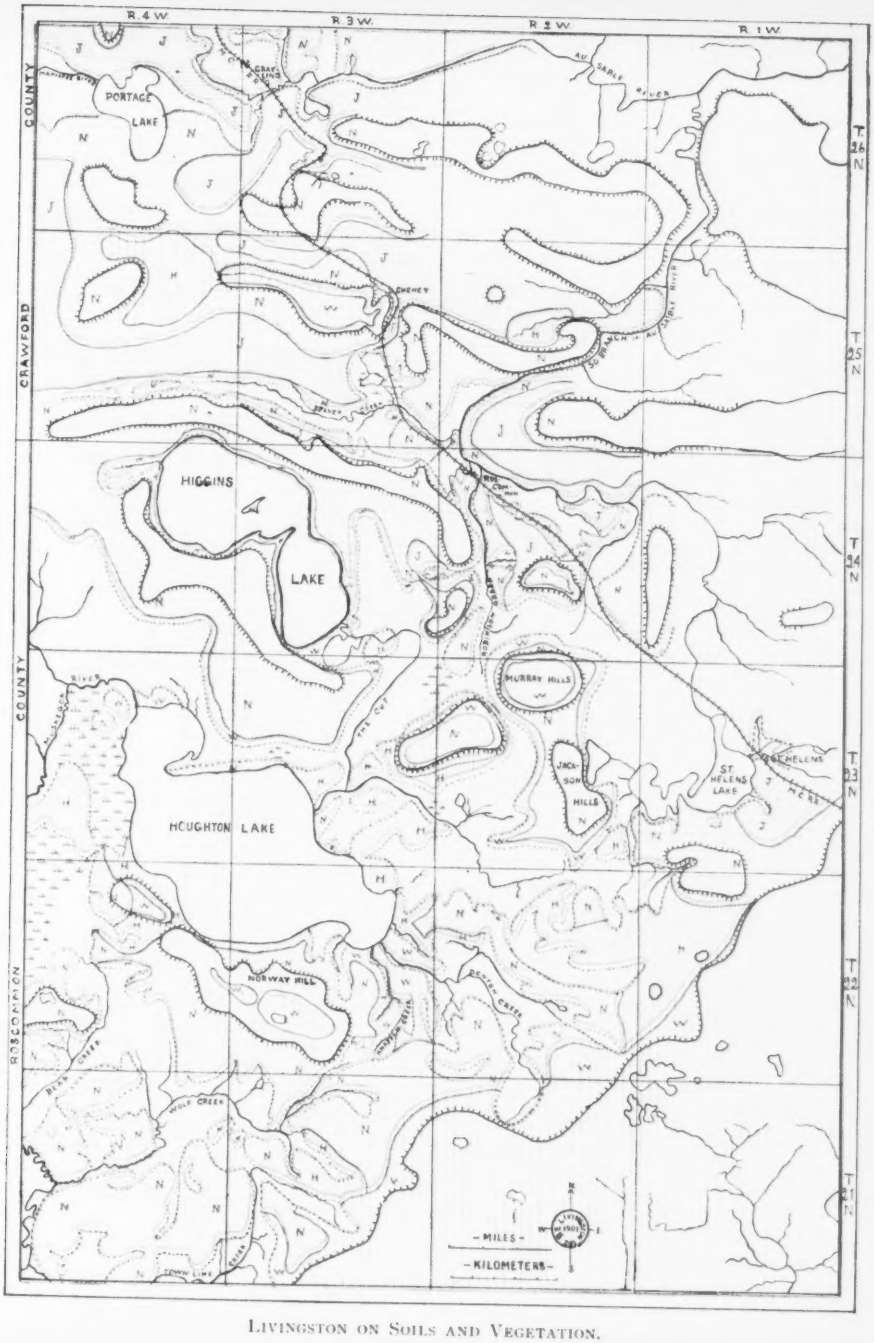

LIVINGSTON ON SOILS AND VEGETATION.

Moraine margin		Clay	
Swamp and channel margin		Clay loam	
Soil margin		Loamy sand	
Vegetation margin		Sand	
Hardwood	H	Norway pine	N
White pine	W	Jack pine	J

area. These ridges are moraines and between them are lower and more level stretches consisting for the most part of plains which slope downward from the ridge margin to the nearest stream. The surface soil of these plains is almost pure sand in many instances, while in others it contains enough more finely divided material to be termed loamy sand. Gravel deposits are very rare and it is seldom that one finds in the plains even scattering pebbles. The moraines are more heterogeneous in composition, containing clay, loam, and gravel as well as sand. An accurate description of these features is to be found in the geological report referred to, and will be here omitted. (See map.)

The soils are nearly all sandy, the only exception to this statement being a few low clay areas and certain clayey portions of the larger moraines. The surface soil of most of the ridges is gravelly and loamy sand, the predominating sand containing a sufficient admixture of finer particles to produce a marked difference in physical properties from that of the true sand plains, while they also contain pebbles and sometimes scattered bowlders. The slopes downward from these ridges are of sand, either pure or loamy, seldom containing many pebbles of any considerable size. The true sand plains, w' h lie at the bottom of some of the valleys, contain little or no loamy material and no pebbles. Their surface is a fine grayish-white sand, which drifts readily by the wind when loosened. Obviously difference in degree of water-washing determines these different soil characters.

Sandy soils are composed of coarse particles and contain much silica, loamy soils are of finer particles and contain considerable quantities of alumina, while clay soils are of still more finely divided materials and contain a much larger percentage of alumina. Since all of this material was transported from the north by the glacial ice, and since it must have been quite thoroughly mixed by this agency, it is reasonable to suppose that, had it not been washed by water during and after its deposit, it would be at least fairly uniform in its mineral constituents. The washing process sorted the soils according to size of particles, but also according to their chemical nature. This is partly due to the fact that alumina breaks down into fine particles more readily than does silica. It is also due to the

fact that in well-washed soils even the less soluble constituents are apt to be actually dissolved and washed out to a greater or less degree. Thus, phosphates and sulfates are less abundant in well-washed soils than in those less thoroughly washed.

In this glaciated region, fine soils, such as clay, were either deposited under the ice of the glacial epoch, and hence not well washed, or else they were deposited from deep and very slowly flowing water. The former variety usually contains many coarser particles, as loam, sand, and pebbles. In the case of loamy soils a good part of the fine material has been washed out, but a considerable amount remains with the sand, so as to give it its loamy character; this is especially true of the ridges. Sandy soils are still more thoroughly washed; the gravel was left farther up stream, on the sides of the ridges usually, while the clay was held in suspension to be deposited at a lower level, where the velocity decreased.

On account of the difference in size of particles, which results from water washing, there naturally follows a corresponding difference in the size of the interstitial spaces of the soil; the finer the component particles, the smaller must be the spaces between them. And because of this there comes to be a corresponding difference in water-holding power and water-lifting power. The surface tension of water films is greater and hence more effective over small surfaces than over large ones, and the film surfaces are greater in coarse than in fine soil. Thus, the smaller the particles of any soil the more water it can hold and the higher it can lift this liquid from a lower level. WARMING[3] quotes WOLLNY as having shown that quartz sand consisting of grains over 1 to 2^{mm} in diameter can hold only one-tenth as much water as that with grains 0.01 to 0.07^{mm} in diameter. SCHIMPER[4] states that loose sand has a water capacity of 15.7 per cent. of its volume, while clay exhibits this property to the extent of 40.9 per cent.

The nature of the soil particles themselves often plays an important part in determining the water-retaining and water-lifting power.

[3] WARMING, E., Lehrbuch der ökologischen Pflanzengeographie, übersetzt von Dr. E. Knoblauch. Bearbeitet von P. Graebner. Berlin. 1902. p. 55.

[4] SCHIMPER, A. F. W., Pflanzengeographie auf physiologischer Grundlage. Jena. 1898. p. 94.

Especially is this true in the case of humus, which is composed of organic débris, decayed plant parts, and to some extent of animal offal. Pure humus has a great power to hold and lift water. This is partly because of its very fine particles, but is also to be traced in part to the actual penetration (by imbibition) of the liquid into the intermolecular spaces of the organic substance itself. Thus, by admixture of humus to a coarse (and therefore porous and permeable) soil, the water capacity of such a soil is increased. The filtering power or permeability to water of a soil increases of course with decrease in its capillary power. Also its permeability to air increases in the same way.

A general exposition of this question of size of particles, water-retaining power, etc., is to be found in either of the works just cited. A much better treatment, however, has appeared in the publications of BRIGGS[5] and WHITNEY.[6] The reader is referred especially to the writings of the former author.

Chemical analyses of a number of Michigan soils have been made and published by KEDZIE.[7] Table I, showing chemical constituents and water capacity, is compiled from his pages, the samples described being all from the portion of the state in which the present studies were made. The first column gives the chemicals found in the soil, in per cent. of dry weight, excepting in the case of water capacity, which is presumably given in per cent. of total volume—although this is not stated in the original papers. The upper tier gives the kind of soil, the location, and the nature of the forest cover.

[5] BRIGGS, L. J., The mechanics of soil moisture. U. S. Dept. Agric., Div. Soils, Bull. 10. 1897.

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[6] WHITNEY, M., The Division of Soils. Yearbook U. S. Dept. Agric. 1897. pp. 120–125.

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[7] KEDZIE, R. C., The jack pine plains. Mich. Agric. Exp. Sta., Bull. 37. Also, 27th Ann. Rept. Secy. State Bd. Agric. 1888. pp. 207–210.

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TABLE I.

SHOWING RESULTS OF ANALYSES OF SOILS OF NORTHERN MICHIGAN.

	Location	Tittabawassee Valley	Mecosta co.	Gaylord	Missaukee co.	Lake co.	Average, 6 samples, Crawford and Oscoda cos.
Physical Description	Nature of soil	Clay	Loam	Loam	Loam	Sand	Sand
	Water capacity	51.40	45.40	39.60	39.10	35.30	33.00
	Forest type	Hardwood	White pine	Hardwood	Hardwood	Jack pine	Jack pine
Chemical Description	Silica	67.20	75.54	91.52	69.39	92.48	94.22
	Alumina	6.31	10.62	2.93	8.35	2.22	.....
	Fe	7.91	3.80	0.90	5.80	1.59	1.88
	Ca	1.64	0.94	0.40	1.15	0.35	0.37
	Mg	1.23	0.48	0.13	0.98	0.30	0.06
	K	1.85	1.96	0.61	1.95	0.73	0.85
	Na	1.15	1.25	0.28	1.15	0.32	0.27
	H_2SO_4	0.30	0.26	0.10	0.25	0.06	0.01
	H_3PO_4	0.49	0.44	0.14	0.28	0.14	0.08
	Organic materials	7.48	2.97	2.20	4.73	1.22	2.16

It will be noticed in the table that sandy soils usually exhibit a marked scarcity of soluble salts. This fact is perhaps to be explained by the "leaching" action of the percolating waters, as well as by the thorough washing to which these soils were subjected at the time of their deposition. The water of precipitation percolates rapidly through these porous soils and may often wash the soluble salts down toward the level of the ground water, this process being termed "leaching."

In humus-covered soils, it is probably not to the point to determine humus content and water capacity after the humus has been mixed with the loamy layers; the effect of the organic substance is very much more marked when the humus lies as a distinct layer on the surface than when it is distributed through the underlying soil. The humus layer acts like a sponge filled with water, and allows the water to pass slowly down into the underlying layers, and thus keeps them moist much longer than they would otherwise be. The samples described above probably were taken from surface soil, perhaps reaching a depth of 20 to 30 cm; nothing is said regarding this question in the reports from which these data are derived.

Table II presents the water capacity of several soil samples col-

lected by the author in Roscommon and Crawford counties. The determinations were made in this laboratory. By "surface" is meant the first 5 to 6^{cm}, by "subsoil" the next 15 to 20^{cm}.

TABLE II.

SHOWING THE WATER CAPACITY OF ROSCOMMON AND CRAWFORD SOILS.

Sample No.	Township	Soil type	Topography type	Forest type	Water capacity volume per cent.	
					Subsoil	Surface
1	21.4	Clay loam	Plain	Hardwood	43.5	74.1 humus
2	22.4	Clay loam	Ridge	Norway	45.9	40.0
3	25.4	Sand	Plain	Jack	37.0	38.0
4	22.4	Loamy sand	Plain	Norway	43.5	....
5	22.4	Clay	Plain	Hardwood	56.9	Mainly humus

It is noticeable that the subsoil of *sample 1* has the same water capacity as that of *sample 4*, but the surface humus of the former brings its water-retaining power up to a point far above that of the latter. The surface of *sample 4* was apparently like the subsoil, containing very little humus.

TYPES OF VEGETATION.

The vegetation of the region may be subdivided into several types or plant societies. These grade more or less into one another, but there are a few places where an observer would be puzzled to determine any particular type. There are to be distinguished four types on the upland and three on the lowland. Practically all of the area under discussion has been lumbered. A virgin pine forest is almost entirely unknown now, though some of the finest pines of the state were cut from here. The hardwood areas have been left almost untouched, excepting for the removal of the white pine originally scattered through them in many places. The hardwood is now being rapidly removed, however, and it will not be long before there will be none left. In the lowlands, the merchantable arbor vitae has very largely been removed, as has been also much of the spruce and even considerable quantities of the tamarack. In the present description there will be presented first a characterization of the original vegetational cover, as well as this can be determined at the present time; then will follow a description of the present conditions.

1. Upland types.

A. HARDWOOD TYPE. There is very little hardwood in the region studied, but it is quite typical of all northern Michigan. Areas so covered have not been so thoroughly lumbered as those covered with pine forests. The original form of this type comprised the following characteristic trees:[8] *Acer saccharum*, *Fagus americana*, *Tsuga canadensis*, *Ulmus americana*, *U. racemosa*, *U. fulva*, *Abies balsamea*, *Betula lutea*, some *Picea canadensis* and *P. mariana*, often scattered *Pinus Strobus* of enormous size, together with such low forms as *Rubus strigosus*, *Mitchella repens*, *Lycopodium clavatum*, *Taxus minor*, *Amelanchier canadensis*, *Lappula virginiana*, *Hedeoma pulegioides*, *Solidago caesia*, etc. Acer, Fagus, and Tsuga make up three-fourths of the forest, now one and now another of the three being dominant.

Lumbering has affected this type very little, excepting by removing the white pine, and in some cases the hemlock. Hardwood lumbering is now going on in the areas covered by this type; in these operations everything is being removed which is merchantable. Fires have not injured this form of forest to any extent, and the original humus usually remains.

B. WHITE PINE TYPE. This is typical pinery, often containing little besides white pine. Usually, however, there is an intermixture of Norway pine (*P. resinosa*), and often of hardwoods. The type is quite sharply distinguished from the preceding, but not nearly so well marked off from the following type, into which it grades in many places. As has been stated, there is at present hardly any of this type in the region under discussion. In lumbering all the pine was removed, and the subsequent fires have killed the young growth of this tree as well as the scattering hardwoods. Over vast stretches originally covered with white pine there are now no trees at all. They are regions of dwarfed *Quercus alba*, *Q. rubra*, *Acer rubrum*, and a number of shrubs. The oaks and maples are rarely more than twice as high as a man, are burned down every few years, and exist here only because of the fact that they sprout from the roots, which are not always killed by the fire. These scrub oaks and maples

[8] The nomenclature is that of BRITTON and BROWN'S *Illustrated Flora*.

thus possess enormous roots which are partially dead or dying, gnarled, contorted, and deformed by frequent burning. For an interesting description of how maples, oaks, etc., are able to attain great age in this manner, and still not be over a few feet in height, the reader is referred to BEAL'S[9] paper on this subject, which is accompanied by convincing illustrations.

Among the lower forms occurring here may be mentioned the following: *Rhus hirta*, *Monarda fistulosa*, *Pteris aquilina*, *Gaylussacia resinosa*, *Vaccinium pennsylvanicum*, *V. canadense*, *Comptonia peregrina*, *Solidago hispida*, *Hamamelis virginiana*, etc. The ground between the blackened stumps is now thoroughly covered by densely growing sweet fern, huckleberry, and blueberry, the growth of the sweet fern being so luxuriant that the numerous prostrate logs are often entirely hidden from sight.

C. NORWAY PINE TYPE. At the time of lumbering, this type consisted mainly of the species for which it is named, but usually contained scattering white pine and more numerous though often dwarfed red and white oaks and red maples. The present aspect of this type is much the same as that of the preceding. The two oaks, red maple, and seedling Norway are the characteristic trees now. Seedling Norways are more numerous than in the preceding type, perhaps because of the greater number of seed trees here, as well as the somewhat greater ability of this species to withstand fire than that possessed by the white pine. The low plants are much the same as in the last. *Solidago caesia* of that type is replaced here by *S. juncea;* and *Lacinaria scariosa* is common here, as it was not in the other group.

D. JACK PINE TYPE. This is the most open of the series and occurs on the most sterile sands of the area. The only trees are *Pinus divaricata*, *Quercus coccinea*, *Prunus virginiana*, and seedlings of *Populus tremuloides* and *P. grandidentata*. All but the pine and oak are hardly more than shrubs. Besides the trees there occur on the jack pine areas the following low plants: *Pteris aquilina*, *Solidago nemoralis*, the three blueberries above mentioned (but rarely the huckleberry), *Arctostaphylos Uva-Ursi*, *Comptonia peregrina*, *Prunus*

[9] BEAL, W. J., Observations on the succession of forests in northern Michigan. 27th Ann. Rept., Bd. of Agric. Mich. 1888. pp. 74–78.

pennsylvanica, P. pumila, Andropogon scoparius, A. furcatus, Danthonia spicata, Lacinaria cylindracea, Salix humilis, Cladonia rangiferina, etc. This style comprises the worst part of what is called the "plains."

2. Lowland types.

For the most part the swamps which were originally wooded have not been denuded of forest. Where they contained white pine, that was taken out, leaving the other trees, which protected the undergrowth and soon produced a dense, almost jungle-like formation. Within the past few years the merchantable arbor vitae and tamarack have been removed from these swamps, but almost always enough small trees are left to produce shade. Also, the swamps have not been subjected to burning nearly so often as the uplands, and are generally in much more nearly their original condition than are the latter. The three types may be described as follows:

E. OPEN MEADOW TYPE. This is partly open hay meadow (largely of "blue-joint," *Calamagrostis canadensis*), partly of bulrush and cat-tail marsh, and partly of sphagnum bog. It grades into the other two types.

F. TAMARACK-ARBORVITAE SWAMP. This is the most typical swamp of the region. It contains *Larix laricina, Thuja occidentalis, Picea canadensis, P. mariana, Abies balsamea,* which form dense and often impassable thickets. In some localities Larix occupies almost all the ground to the exclusion of other trees, and in other places the same is true of Thuja. But there is not nearly so much tendency here for these two trees to form separate and distinct types as is found farther south.[10] There the tamarack seems to occupy the portions of the swamp lands which are most poorly drained, the arbor vitae growing in localities where drainage is more thorough, yet still not complete enough for the river swamp vegetation. Here the question of drainage does not appear to play so important a part.

G. MIXED SWAMP. This formation is found near swamp margins, especially where the underlying clay is near the surface. Thus it often occurs along lines where the hardwood forest reaches down

[10] For a description of the conditions farther south in the state, the reader is referred to the author's paper on Kent county, *loc. cit.*

toward a swamp. It may be looked upon as intermediate between the tamarack-arborvitae type and that of the hardwood. There is always a great mingling of species here. Among the trees are; *Larix laricina, Thuja occidentalis, Picea mariana, P. excelsa, Abies balsamea, Betula papyrifera, B. lutea, Fraxinus americana, Tsuga canadensis, Sorbus americana, Acer saccharum, Prunus serotina, Pinus strobus, Amelanchier canadensis*, etc., together with such low forms as *Rubus strigosus, R. villosus, Pteris aquilina, Lycopodium clavatum, Taxus minor, Alnus*, and *Ilex verticillatus*. The relative proportions of the different trees vary from one locality to another, so that nothing definite can be stated in this regard.

DISTRIBUTION OF FOREST TYPES.

The actual distribution of the types is shown by green lines on the accompanying map. The upland types are denoted by letters, each area bearing a letter to denote the type which it represents. Thus, *H* denotes hardwood; *W*, white pine; *N*, Norway pine; *J*, jack pine; and these letters stand for types *A*, *B*, *C*, and *D*, respectively. Of the lowland formations the open meadow is represented by the conventional sign for marsh where it exists over broad areas.

The main facts of distribution are presented in the following paragraphs. The upland and the lowland types will be considered separately.

Uplands.

The hardwood type occurs in this region always on soils which contain considerable amounts of clay. Such soils are always covered to a depth of several inches with leaf mold or humus, and in this layer the seedlings of hardwood and hemlock grow and thrive.

The white pine type occurs in the clayey Murray Hills, on the most clayey parts of Norway Hill, and on the great southeastern moraine, in T. 21 N., R. 2 W. These soils are often as clayey as those of many of the hardwood areas, but are higher and therefore better drained. It also occupies most of the gravelly ridge in T. 25 N., R. 2 W. Very often the swamp margins are occupied by this type also, especially where the slopes are not abrupt, a condition which gives humus a chance to collect in the sand.

The Norway pine type occupies gravelly ridges and loamy sand plains. The soil here is somewhat lighter than in the locations held by the last-named type, but it is generally too poor for profitable agriculture. As will be seen by a glance at the map, most of the uplands here studied were originally covered by this type.

The jack pine type occupies only the most thoroughly washed of the sand plains. The localities held by this open formation lie in the valley of the Au Sable. The parts lying about the headwaters of the Muskegon have abundant plains of loamy sand, but these support the type of Norway pine. This fact has no connection with the rivers themselves, however, for farther down the Muskegon are to be found typical jack pine barrens. The soil of the jack pine type is almost worthless for agriculture; it is light and dry, and where the surface is broken it is apt to be wind-blown, and often forms small traveling dunes.

Lowlands.

The distribution of the lowland type was not worked out with accuracy. Great difficulty was experienced in studying such areas, for the swamps are often almost utterly impassable. The greatest areas of open marsh encountered are marked on the map, as already described. There are doubtless many areas of like nature which were not seen at all, but these cannot be of very great extent. In all the swamps the ground is covered with a layer of humus, usually of the nature of peat, and there seems to be no difference in this substance between the sand and the clay areas. Neither is there any apparent difference in the swamp vegetation whether it is upon sand or clay.

RELATION BETWEEN DISTRIBUTION OF FOREST TYPES AND THAT OF SOIL TYPES.

The upland types seem to be very closely dependent upon the nearness of the underground water level to the surface and upon the nature of the soil. The former factor determines at once whether the vegetation shall be classified as upland or lowland. The distinction between these two classes is more evident on the surface than it is after closer study; it is difficult to state just how far the water level may recede from the surface and still support a lowland

type of the forest. Very few determinations have been made in this regard. MAYR[11] states for northern Wisconsin that where the water level is less than 2.5^{cm} below the soil surface, the vegetation is of the swamp form; while if it is lower than 2.5 to 5^{cm} the soil bears white pine or some other upland type. This was on sandy soil. WARMING[12] has determined the depth of water level in various soils in Denmark. He finds Juncus and Carex forms holding the ground until the water level is about 22.5^{cm} below the surface; with water at a depth of 30 to 37.5^{cm}, grasses grow well, forming what we should term a moist meadow. With the water from 45 to 60^{cm} below the surface, all grains grow well; this seems to represent our fertile uplands. With the water still lower the soils becomes poor for grains. Data from natural vegetation, so far as I know, have not been gathered.

The more water there is in a soil, the less is the access of air to the roots of plants growing therein. This is because air diffuses much more slowly when in aqueous solution than when in the form of a gas. Gas diffusion is checked by the filling of the interstices of the soil with water, and hence most of the oxygen which reaches roots in wet soil must do so by diffusing as a solute in the water. Some ordinary plants cannot grow without rather free access of oxygen to their roots, and so it follows that a soil saturated with water is very poorly adapted to their growth.[13] This is probably the main reason why saturated soils are usually occupied by a vegetation differing entirely in aspect from that found on soils which are drier; thus we have swamp or lowland types of vegetation contrasted with upland types. Swamp plants are able to live with a scanty supply of air to their roots; but since upland plants cannot, it is possible to have too much water in the soil for the well-being of the latter. Thus areas with much water are occupied by typical swamp plants, often perhaps because they alone are able to live in this situation.

[11] MAYR, H., Die Waldungen von Nordamerika. München. 1890.

[12] WARMING, E., Excursionen til Skagen i Juli 1896. Bot. Tid. **21**: 59–112. *figs.* 4. 1897. I am indebted to G. H. Jensen for an abstract of the article.

[13] WOLLNY, E., U. S. Dept. Agric. Exp. Sta. Record **4**:528–543, 627–641. 1893.

1. Factors of distribution in the uplands.

ORIGINAL DISTRIBUTION. Throughout the uplands, excepting in the narrow swamp borders and in the low clay plains about Houghton Lake, the underground water level is far from the surface, its depth varying from 3 to 25^{m} or even more.

Wherever the upland group occurs near the water level, it takes the form of one of two types, either the hardwood (on the low clay) or the white pine (on the low sand and loam). Farther above permanent water the former of these types occurs only in one locality, in the northwestern part of the area, and there upon loam. Where the water level is not near the surface, the white pine type occurs only on clay and loam. The Norway type is found throughout the area on loamy, or loamy and gravelly sand, and the jack pine type appears exclusively on sand which is hardly at all loamy and thoroughly washed. The distribution of the upland types just described may be tabulated as follows:

	POSITION OF UNDERGROUND WATER LEVEL.	
Soil	Near surface	Deep
Sand	B, C	D
Sandy loam	B, C	C
Clay loam	A, B	B (A)[14]
Clay	A, B	B

In the above table the different types are denoted by the letters already used in their description. It will be noticed that from clay to sand, with water level deeply seated, we have a series passing from the white pine type to that of the jack, through the Norway. A single exception to this is the hardwood area on clay loam in T. 25 N., R. 4. W, to be spoken of in a later paragraph. But with the water level near the surface, the series runs from the hardwood to the Norway type, the jack pine not occurring at all. This observation seems to agree with those made by MAYR[15] in northern Wisconsin. He states that sand ridges rising out of the swamps usually bear white pine on the slope, then Norway, and lastly the jack on the most elevated parts. The same author points out that white pine will grow on poor sand if the water is only near the surface. The same seems to be true here also.

[14] The hardwood in T. 25 N., R. 4 W.

[15] MAYR, H., *loc. cit.*, p. 207.

To explain the distribution of the different types, either of two hypotheses may be resorted to. As has already been mentioned, the finer the particles of the soil, the greater its power to lift and hold water above the underground level. It is well known, too, that some soils contain more of certain salts than do others. Thus, the reason for the observed distribution on the uplands may be sought for either in the water-retaining power of the soil or in its chemical constituents.[16] That the depth of the water table itself sometimes plays an important part in determining plant distribution is shown by the above table. Along a swamp margin the increased amount of water may influence the plant growth directly, but how much of the observed influence is to be considered as indirect is an open question. The presence of water alters a number of other soil factors.

First, it checks free access of air. Thus, if jack pine roots need more air than do those of Norway, this might explain why the former fails along the swamp borders and the latter takes its place.

Secondly, with increase in water content there follows a more equal distribution of the dissolved salts, for these can diffuse only through continuous water films, and the greater the cross-section of the latter, the more rapidly will diffusion take place. As a corollary to this statement, it follows that "leaching," the washing down of soluble salts out of the upper into the lower strata, cannot occur to any great extent in a soil which is constantly filled with water. Moreover the upward diffusion of salts during dry times would probably more than counteract the downward washing during heavy rains. The upper layers of a wet soil are apt to have more soluble salts after they have lain for a time than when first placed. This is of course on account of the evaporation at the surface, which increases the concentration of the soil solutions in the upper layers. Of course

[16] For early papers on this subject see:

THURMANN, J., Essai de phytostatique appliquée à la chaine du Jura. Berne. 1849.

NÄGELI, C., Sitzungsber. Akad. Wiss. München. 1865.

UNGER, Ueber den Einfluss des Bodens auf die Verteilung der Gewächse. Wien. 1836.

A more recent paper dealing with this question of soil physics and soil chemistry as influencing vegetation is COWLES, H. C., The influence of underlying rocks on the character of the vegetation. Bull. Amer. Bureau of Geog. **2**:1–26. 1901.

this indirect effect cannot be exhibited unless there is a sufficient amount of salts in the deeper lying soil. But in a glaciated region such as this, there can be little doubt as to the presence of these relatively near the surface.

Thirdly, the checking of air access, coincident with the filling of the pores of the soil with water, must check the process of oxidation and thus accelerate the formation of humus. This seems to be a very important factor in determining vegetation.

Fourthly, the growth of micro-organisms in the soil, bacteria, etc., takes place much more rapidly in a moist than in a dry soil. However, excess of water is deleterious to the growth of many of these organisms, so that a soil may be too wet for them; but flooding is not so fatal in sand as in finer soils.[17] It is well known that soil bacteria and mycorhizal forms are very important in increasing the amount of nitrates in the soil, and thus it appears that a moist soil, even a wet soil, if it be sandy, will gain nitrates much more rapidly than a dry one.

The comparative rapidity of temperature changes in moist and dry soils may have considerable importance in regard to plant growth. A dry soil is subject to much more sudden and rapid changes of temperature than is a moist one when the soils are exactly alike, as I have shown by actual tests.

The points of difference between a moist and a wet soil may be tabulated as follows:

Condition of soil	Dry	Moist	Wet
Water for roots	Too little	Enough for most plants	More than needed for most plants
Soluble salts originally near surface	Sometimes leached farther down	Still near surface	Still near surface
Soluble salts originally in lower layers	Sometimes leached farther down	Partly in upper layers	Partly in upper layers
Humus content	None	Some	Plentiful
Oxygen content	Plentiful	Some	Little
Micro-organisms	None	Optimum	Few
Nitrates	Little	Much	Some
Temperature changes	Rapid	Less rapid	Slow

Whether these points are determined by nearness of the underground water level or by the capillary power of the soil, there appears to be no doubt that the amount of water in the layers near the surface practically determines the nature of the vegetation in this region. Besides the general discussion of this matter to be found in

[17] GAIN, E. Action de l'eau du sol sur la végétation. Rev. Gén. Bot. **7**: 16–26, 71–84, 123–137. 1895.

WARMING and SCHIMPER (*loc. cit.*), the reader may refer to GAIN[18] and HEDGCOCK.[19]

Of the upland series, the hardwood type of vegetation seems to need the most water, the most soluble content, and the most humus. Probably this is the reason why this type occupies the moister soils of the upland, no matter whether these are moist through nearness to the underground water table or through the lifting power of the soil itself. The types of white, Norway, and jack pines seem to require less water in the order of their arrangement. Probably the Norway and jack pines require more air in the soil than either the hardwood or the white pine. The typical tree forms of both these last-named types occur in the mixed swamp quite commonly, but I have yet to see either Norway or jack pine in soil which is wet the greater part of the year. Throughout the region it seems that each type occupies soils which correspond in water content to its needs. It must be remembered here that a sandy soil near the water level may contain much more water than a loamy one where the water is farther from the surface. This idea offers a possible explanation for the occurrence of hardwood on low loam in T. 25 N., R. 4 W. Addition of surface humus has also, perhaps, raised the water holding power of the soil to the neighborhood of that manifested by clay itself. The subsoil is such here that the white or Norway type might be expected.

PRESENT DISTRIBUTION. The statement so frequently met with that white pine will not come up after it has once been cut off and the ground burned over seems to strike wide of the truth in this region. I have visited almost every square mile of the uplands and am thoroughly convinced that scattering seedlings of white pine are now evident on practically all areas originally covered by that species, which have not been recently subjected to the action of fires. Seedlings of the Norway, however, are now more numerous on these areas than are those of the white pine itself. They are plentiful throughout the region on light soils excepting the very lightest.

[18] GAIN, E., Recherches sur le rôle physiologique de l'eau dans la végétation. Ann. Sci. Nat. Bot. VII. **20**:65–215. 1894.

[19] HEDGCOCK, C. G., Botanical Survey of Nebraska: Studies in the vegetation of the State, II. Lincoln. 1902.

Fires prevent the young growth of the white pine and also prevent humus formation. Thus, as long as the latter are allowed to continue, the water capacity is not apt to rise and the growth of nitrifying bacteria is not apt to increase; but the presence of a few white pine seedlings is evidence that the species can grow if protected. Indeed the best young stands of any kind that I have seen are of this tree, and they promise exceedingly well for reforestation.

As has been said, the Norway pine is coming in quite freely in the areas originally covered by this species and the white pine. The degeneration goes no further, however; I have almost never seen even individual jack pines appearing in any of these areas. Indeed, there is some evidence that the Norway pine is gradually advancing its seedlings into the areas held by the jack pine.

The hardwood forest reappears quite rapidly when cut. This is doubtless in part due to the fact that this material does not burn so readily nor so violently as do the pines. The scattered white pines which formerly characterized some of these forests in the eyes of the lumberman are not returning. They are perhaps only a relic of a past generation of forest.[20] Hemlock is reproducing well and will return with the beech and maple if through lack of humus the soil does not become too dry for the seedlings. The sugar maple is the best for reclaiming cut-over lands. Its seedlings stand close together and do not seem to suffer from one another's shade.

The work of SHERRARD[21] in this region resulted in a map and statistical study of the tree growth of township 25 N., R. 4 W, as well as a general discussion of the forestry conditions of the reserve. The township thoroughly studied by this author originally contained practically no white pine, but the other types are well represented. SHERRARD'S "oak flat" and "oak ridge" are all original Norway pine land. For statistics of growth, etc., the reader is referred to his paper.

[20] See the author's Kent county paper, *loc. cit.*; also WHITFORD, H. N., The genetic development of the forests of southern Michigan. BOT. GAZ. **31**: 289–325. 1901.

[21] SHERRARD, T. H., The Michigan forestry reserve. Report Mich. Forestry Commission **1902**: 28–54. 1903.

2. Factors of distribution in the lowlands.

The three types of lowland vegetation seem also to follow in some degree the conditions of soil moisture. In this case it seems better, however, to arrange the types in the reverse order and to present them as following conditions of drainage. As has been stated, all three types are composed of forms which can withstand a great deal of moisture. No positive evidence can be given as to whether or not there is any difference in water content between the soils of the open meadow and those of the tamarack-arborvitae forest. Nothing has been made out regarding the conditions which decide in favor of one or the other of these; but the mixed type is always found on the better drained portions, where there are hummocks raised out of the saturated soil, and where the general level is a few inches higher. Often this better drainage seems to come about merely by accumulation of vegetable débris, a fact which suggests that perhaps in time the conifer swamp might give way to the mixed, and at last possibly to the hardwood upland type.

Attention has already been called to the fact that this series of types have not been seriously altered by the hand of man. The large white pines have been taken from the mixed swamps, as have also many of the most valuable tamaracks and arbor vitae, but the forest conditions have not generally been destroyed.

RELATION OF THE VEGETATION TO THAT OF KENT COUNTY.

The predominance of the pines in the region under discussion is an expression of the fact that the flora here is a typical northern one. Only one pine (the white) is found in Kent county, and there it grows in poorer soil than it holds here. The presence of hickory and the better growth of the black, red, and white oaks in the more southern area is an indication of a more southern flora. The factor which keeps the jack pines out of the more southern county may be a climatic one; this species occurs with the white pine on the dunes at the extreme southern end of Lake Michigan.

The hardwood forests of the two regions are very nearly the same in character. In the northern part of Kent county the hemlock begins to be an important tree in this group, as it is farther north.

A study of the transition zone between these two areas will be necessary before the working out of the exact relation of the various societies can be attempted.

RELATION OF THE VEGETATION TO THAT FARTHER NORTH.

The student of plant distribution who has formed any definite theories as to the relation of plant societies to topography and soils from the southern part of the state and from Indiana and Illinois will be much surprised if not actually shocked by a visit to the region of the straits of Mackinaw. On the island of Mackinac, for example, occur most of the tree forms found in Kent county, but growing apparently without relation to the soil condition. Norway and white pines, beech, sugar maple, red maple, tamarack, arbor vitae, balsam fir, basswood, etc., will be found growing side by side on the well-drained uplands in clay or sand or loam, or even partially bare rock. As to the reasons for this nothing can be said before more of the area has been studied in detail.

CONCLUSION.

It appears from these investigations that the main factor in determining the distribution of the forests on the uplands of this region is that of the size of soil particles, the sorting of which dates back almost entirely to the close of the last glacial epoch. The size of particles determines the amount of air and moisture in the soil, and these in turn determine the amount of humus formation and the growth of nitrifying organisms, and perhaps also to a certain extent the amount of soluble salts in the surface layers.

A factor of less importance, because applicable only over small areas, is the nearness of the underground water level to the surface. This affects the uplands only along swamp borders.

In a broad way, physiography may be said to determine the vegetational distribution here.[22] The physiographic features are largely ones of glacial topography or are traceable directly to these. Geological factors, in one way or another, have of course determined

[22] For an excellent elaboration of this idea see COWLES, H. C., The physiographic ecology of Chicago and vicinity. BOT. GAZ. **31**:73–182. 1901. Also, The plant societies of Chicago and vicinity, Bull. Geog. Soc. of Chicago **2**:1–76. 1901. Also, The physiographic ecology of northern Michigan, Science N. S. **12**:708, 709. 1900.

the distribution of surface soils and the distance below the surface of the ground water level.

It is probable that many dry soils may at length become moist enough to support one of the more moisture loving types of vegetation, simply by increase of humus content, which must go on slowly at first but more rapidly as the amount increases. This is merely an application of one of the general principles of forest succession pointed out by WHITFORD (*loc. cit.*).

The lowlands are covered with a vegetation complex of species such that they can bear excess of water and paucity of oxygen in the soil. From the open meadow and coniferous swamp we pass, with better and better drainage, through the mixed swamp to the hardwood or the white pine of the uplands.

It appears that the natural reforestation of the pine areas, with Norway pine, and to some extent at least with white pine, will take place if the fires can be suppressed.

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NOTE.— Since the preparation of this paper, a similar conclusion has been reached in regard to sterility in agricultural soils by WHITNEY and CAMERON, Bull. 22, Bureau of Soils, U. S. Dept. Agric. 1903. Also, it has been shown by actual field test that coarseness of soil particles alone can produce sterility in spite of a plentiful supply of water. See LIVINGSTON and JENSEN, An experiment on the relation of soil physics to plant growth. BOT. GAZ. 38: 67–71. 1904.

NEW AND NOTEWORTHY WESTERN PLANTS. II.

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In the spring and summer of 1902, while engaged in a collecting trip in western Santa Barbara, eastern Ventura, and portion of northeastern Los Angeles counties of California, a number of noteworthy plants were collected as well as new species discovered. On the train from Stanford University to Santa Barbara, where my headquarters were made, I was impressed with the surroundings of Surf as having peculiar physical characters. Having no time to examine the vegetation then, I observed nevertheless a palmlike bush with large golden yellow flowers which I did not notice farther south. Curious to know this plant, I made a side trip to Surf in May, and found its local sand-dune flora the most interesting of all the vegetation in the counties visited. Surf is near the coast and has a stretch of sand dunes a few miles in length and a half mile in width. The breakers are active most of the year, and the winds at certain seasons are continuous and strong; at such times the sands are shifting almost knee-deep. The temperature is always moderately cool. This place is one of the few points along our coast possessing more striking peculiarities than the ordinary sea beaches. It is a place where the oceanic influences are predominant. One can imagine similar conditions on the Santa Barbara Islands off the mainland of southern California. It is my conviction that if a critical study were made, comparing the island flora with that of the mainland such as we have at Surf, a striking similarity would be discovered. Of the following species, all are described as new excepting the first four, and the first seven were collected in the vicinity of Surf. Some of these seven have already been reported from the islands, and the others may be assumed to belong to the island flora.

Dithyrea californica Harv.—This peculiar crucifer I collected on the sand hills at Surf, and it was collected again in the Mohave desert at Lancaster, Los Angeles county, California. It seems to extend from the coast of southern California northeastward through the Mohave desert to Nevada. So far as I am aware, Surf is the

most northern limit of its distribution along the coast, and it may be expected on the Santa Barbara Islands.

MESEMBRIANTHEMUM CRYSTALLINUM Linn.—This beautiful ice plant seems to love halophytic conditions along drifting sand beaches continually swept over by cool winds from the ocean, though it has also been reported from the Mohave desert by Mrs. BRANDEGEE, according to PARISH. Along this coast its range extends from Surf, Santa Barbara county, California, southward through Lower California, and on the islands off the coast. It is an old world species, indigenous to the coast of Africa.

LEPTOSYNE GIGANTEA Kellg.—This is the plant observed from the moving train as a palmlike bush with large golden yellow flowers. Aside from the original publication, the *Botany of California* reports it from Guadalupe Island and San Miguel of the Santa Barbara Islands. The *Synoptical Flora* gives it from the mountains near Santa Barbara and San Miguel, and the islands off the coast. This citation is rather obscure, and it is to be doubted whether this plant was discovered on the mainland as early as that date. In Bull. Calif. Acad. **4**:402. 1887, GREENE writes that he found it frequent on cliffs toward the sea on the north side of Santa Cruz Isand, and reports it flowering as early as February and March. Miss ALICE EASTWOOD reported it for the first time from the mainland, and in Zoe **4**:286. 1893–4, she writes that JARED found it growing abundantly near the old wharf at Point Sal, Santa Barbara county.

CEANOTHUS IMPRESSUS Trel.—About twenty-four years ago JARED collected southwest of Guadalupe toward Point Sal, Santa Barbara county, California, a Ceanothus of which TRELEASE wrote in *Proc. Calif. Acad.* II. **1**:112. 1888:

> *C. impressus*, n. sp. Villous with short spreading hairs: leaves broadly elliptical to nearly orbicular, 6–8^{mm} long, loosely villous, especially on the veins below, the upper surface deeply furrowed over the midrib and several pairs of lateral nerves, the slightly glandular margin very revolute, appearing as if crenate: peduncles about 10^{mm} long, scaly toward the base; inflorescence subglobose, compact: fruit not seen.—Santa Barbara county, Cal.

About fifteen years later Mrs. IDA BLOCHMAN collected it again near the same place. While botanizing a few miles north of Surf station I found a Ceanothus (distributed under number 3870) which

seems to answer well to the above diagnosis. Its range appears to be restricted to this coast, and it should be looked for on some of the northern Santa Barbara Islands. In Proc. Calif. Acad. II. **4**:202. 1894–5, Mrs. KATHERINE BRANDEGEE writes that in her opinion it appears to be nothing but a stocky southern form of *C. dentatus* T. & G. growing on unsheltered sandhills. In the same paragraph she states that *C. dentatus* in its typical form appears to be confined to the vicinity of Monterey. Still there are quite remarkable differences between the two forms or species, and to one observing them in the field they would not for one moment be taken for the same. *C. dentatus* at Monterey has not the dense prostrate habit. The leaves of *C. impressus* are broadly elliptical to nearly orbicular, while in *C. dentatus* they are oblong-cuneiform; furthermore, the branches of *C. impressus* are rigid and spinescent, while in *C. dentatus* they are flexible and not spinescent—a character also contrasting *C. thyrsiflorus* Esch. and *C. sorediatus* H. & A.

Malacothrix succulenta, n. sp.—Succulent maritime perennial herb, with long fleshy creeping and numerously branched stems forming dense mats: stem above the sand branching near the base or at least below the middle, 1–2^{cm} high, rarely erect but usually reclining, when young floccose especially on the concealed portion, soon becoming glabrous: lower leaves persistent after they become dry, linear-oblanceolate, sessile when mature, glabrous on both sides, 5^{cm} long, 8^{mm} across the widest part, obtusely rounded, rarely undulate or dentate along the upper margin: scapes gradually thickened at the apex, usually branching from a little below the middle, its bracts minute, weak and sub-flexuose: heads solitary, turbinate, 2^{cm} long, about that in width at the top: involucral bracts chiefly in one series, 10^{mm} long, thin, glabrous, linear, loosely imbricated, subtended by numerous smaller triangular bracts of the scape: flowers many, all with lemon-colored ligulate corolla: receptacle naked, flat: achene smooth, 1.5^{mm} long, with semi-truncate or short obtuse ends, bearing a soft silky white pappus whose bristles are finely scabrous and equally 6^{mm} in length: corolla 7^{mm} long, gradually tapering into the 4-toothed ligulate expansion, much exceeding the pistil, its tube 3^{mm} long and glabrous: stamens exserted; anthers linear, united, 3^{mm} long; filaments 5^{mm} long, distinct, thread-like style exceeding stamens, barely cleft.

Dunes and terraces about Surf, Santa Barbara county, California, May 1902. Type specimen, no. 3639, in Herb. Stanford University.

It is now just sixty-six years since NUTTALL first discovered on an island in San Diego Bay a Malacothrix which Torrey and GRAY described (Fl. N. Am. **2**:486. 1838–40) as *M. incana*. Fifty years later GREENE rediscovered it growing abundantly on San Miguel, the smallest and remotest of the Santa Barbara Islands; he also found it on the western extremity of Santa Cruz Island, a distance of 200 miles northwestward from its type locality. My plant from Surf is similar, but in my opinion is specifically distinct, though very closely related to *M. incana*.

Carduus maritima, n. sp.—Succulent maritime biennial or perennial, from strong thick tap roots: stems 1^{m} long, much branched from the base and up to the middle, giving the plant a rounded bushy appearance; branches covered with long white appressed hairs and terminating in 1–3 heads: leaves thick, felty, densely and thickly lanate pubescent, $1–2^{cm}$ long, the blade proper ovate in outline, the lower one-third abruptly narrowed, its base semi-auriculate, the entire margin irregularly and dentately lobed and beset with straight needle-pointed spines which are more numerous toward the base than on the coarse lobes of the blades: heads large, dull white, 5^{cm} long, nearly that in width, loosely corymbose: bracts many, imbricate, nearly equal in length; the exterior ones similar to the leaves in lobation, spinescence, and pubescence; the interior ones linear-lanceolate, sharply acuminate, the lower and inner surface wholly glabrous, finely spinescent on the margins above the middle: the dense bristly hairs of the receptacle not hispid, dark brown, 12^{mm} long: achene 6^{mm} long, flattened, narrowly obovoid or cuneate, brown and shining, usually somewhat curved: pappus bristles interlaced with fine secondary ones except at the apex, 2^{cm} long, dull white, attached as a whole to the apical rim of the achene: corolla tubular, 2.5^{cm} long, segments 4^{mm} long, the tube funnelform or slightly inflated immediately beneath the lobes: anthers united and pubescent, 7^{mm} long: stigma barely notched.

Surf, Santa Barbara county, California, May 1902. Type specimen, no. 3631, in Herb. Stanford University.

The habitat of this species is strictly saline and most probably it can be found on the islands and possibly in other localities along the coast. I found only a few plants on the most exposed dunes, on which they formed low spreading bushes not very dissimilar to the Russian thistle. Its low succulent halophytic habit, remarkable pubescence and peculiar lobation and spinescence of its leaves readily distinguish it from all other species of this genus.

Monardella crispa, n. sp.—A low strongly aromatic shrub, 3^{dm} high, the lower woody branches numerous, giving it a small dense bush-like appearance; younger branches lanate pubescent, older ones with thin coarsely and irregularly checked bark: leaves sparsely lanate pubescent, somewhat succulent, fascicled at regular intervals, more strongly punctiform on the dorsal surface, the larger ones $2–3^{cm}$ long and 1^{cm} wide, undulate or coarsely crisped along the margins below the rounded apex, oblong or narrowly oblanceolate with a long attenuate base; upper pair of leaves ovate to oblong, without the slenderly narrowed base: heads solitary upon the stems or branches or in a series of two or even three, sub-globose, $2–4^{cm}$ across, upon densely woolly scapes $2–5^{cm}$ long: bracts 10^{mm} long, apex acute or rounded, thin, purplish, the 3–7 nerves conspicuously ascending, the outer surface soft pubescent, almost equaling the calyces, the exterior ones elliptic to broadly oblanceolate, the interior ones narrower and a trifle shorter: flowers 18^{mm} long, upon pedicels 1^{mm} long: calyx tubular, 6^{mm} long, woolly pubescent, 14-nerved, the 5 acute teeth 1^{mm} long: corolla 13^{mm} long, light pink, obscurely bilabiate; upper lip broad, deeply emarginate; lower one divided into 3 ligulate segments; exterior corolla tube 4^{mm} long, exceeding the calyx, sparsely set with fine short recurved hairs: stamens 4, spreading and much exserted: style included, bearing a short-lobed stigma.

Surf, Santa Barbara county, California, May 1902. Type specimen, no. 3965, in Herb. Stanford University.

This mint is a maritime species, and at Surf is confined to the drifting sand beaches. Without much doubt it may also be found on some of the Santa Barbara Islands where the sea influence is strong.

Monardella robusta, n. sp.—Faintly aromatic, tall, woody, $1–2^{m}$ high, prostrate or supported by other undergrowth: stem almost scape-like below, with a few branches toward the top, covered with a thinly checked but not shredded bark; younger branches dark brown, sparsely pubescent, usually terminated by a solitary head though often bearing smaller axillary ones beneath them: leaves opposite, the larger ones 5.5^{cm} long including the 5^{mm} long petiole, 15^{mm} wide, lanceolate, margins involute, coriaceous, nerves radiating from the midrib and ascending, prominent beneath, sunken above, entire or obscurely crenately toothed, puberulent or only sparsely

hirsute on dorsal surface, thickly white lanate pubescent beneath, sub-scarious; axillary leaves shorter and narrower, fascicled, without a distinct petiole: heads 2^{cm} or more across, less than that in height, solidly flowered, nearly sessile or pedunculate; the lower bracts shorter and broader, 8^{mm} long, broadly elliptic, acute or obtuse, ascendingly nerved mainly from the broad base, soft pubescent, especially upon outer surface: flowers short pedicellate: calyx tubular, 8^{mm} long, 14-nerved, terminated by 5 acute teeth 1^{mm} long: corolla at least 2^{cm} long, its tube exceeding the calyx teeth by 4^{mm}, scarcely bilabiate, lower segments 6^{mm} long, exterior of exserted tubular part set with fine retrorse hairs: stamens 4, exserted: style slender, mostly included, 2-notched.

Rattle Snake Canyon, a few miles back of Santa Barbara towards the Santa Ynez Mountains, Santa Barbara county, California, August 1902; rare, and only found in dense thickets of underbrush. Type specimen, no. 3728, in Herb. Stanford University.

Encelia actoni, n. sp.—Shrub 1^{m} high, moderately branched, forming rather unique individual bushes; wood soft; bark thin, smooth, grayish white, becoming finely checked and ultimately shredded: leaves not crowded, nor are the secondary ones fascicled, 3^{cm} long, 2^{cm} wide, ovate, acute, chiefly entire, 3-nerved at base, alternate, without stipules, cinereous pubescent, upon petioles 1^{cm} long: heads 3^{cm} in diameter, solitary upon long cinereously pubescent scapes barely bracteate below the middle: involucral bracts nearly of the same size, $7–10^{mm}$ long, $3–5^{mm}$ wide, imbricate in two or three series, hispidly pubescent and sub-glandular on the exterior, glabrous on the interior: ray flowers pubescent, tube bearing a pistil and gradually expanding into a truncate ligule 8^{mm} long, not numerous, with a sterile achene 4^{mm} long; ligule proper finely pubescent on the outer surface, light yellow, many-nerved; disk flowers perfect and fertile, subtended by bracts; these 10^{mm} long, strongly enfolding the achene, with a prominent midnerve besides the 10–14 lateral nerves terminating in an acute glandular pubescent apex whose edges are fimbriate: corolla tubular, equaling the achene, lower one-fourth constricted, terminating in rather acutely thickened recurved apical segments: stamens included; filaments 1^{mm} long; anthers 5^{mm} long, introrse, with triangular apex, and minutely sagittate base: style 2-cleft, stigmatic only upon the upper outer side of the lobes;

achene 5^{mm} long, much compressed, narrowly obovoid or cuneate, only the edges densely ciliate especially toward the apex.

Acton, Los Angeles county, California, June 1902. Type specimen, no. 3724, in Herb. Stanford University.

This interior species differs from the seacoast *E. californica* Nutt., and can at once be distinguished in the field by its conspicuous light grayish bark, its cinereous pubescence, its fewer and larger heads, and its individual habit.

Chrysopsis californica, n. sp.—Perennial, $4–6^{dm}$ high, from woody base: stem long silky pubescent, fastigiately branching, terminating in a subcorymbose inflorescence: leaves more or less fascicled, sessile, often clasping, the average length 2^{cm} and width 5^{mm}, though often much shorter or longer, granular surface covered with dense white silky pubescence, edges becoming involute: heads 2^{cm} broad, upon short leafy ascending peduncles: involucral bracts many, villous pubescent on exterior surface, linear or narrowly lanceolate, regularly imbricated in several series: receptacle naked: *ray flowers:* pappus 2-seriate; the upper of reddish-brown scabrous bristles 6^{mm} long, the lower lighter colored; minutely paleaceous, only 0.5^{mm} long: corolla 2^{cm} long, lower half tubular, upper expanded into a semi-obovate or oblanceolate ligule which is closely and minutely 3-toothed at apex; opposite this primary ligule is usually present a secondary one which is shorter, more linear and inserted upon its throat: *disk flowers:* pappus bristles in one series, 2^{mm} long: corolla glabrous and tubular, with rich yellow acute segments, 1.5^{mm} long: filaments short, separate, inserted upon a short thick base: style exserted and deeply cleft, the branches triangular acuminate and stigmatic only on exterior surface; achenes apparently all fertile, 4^{mm} long, short pubescent, slightly compressed or 4-costate.

Sandy soil near the beach, Gaviota, Santa Barbara county, California, May 1902. Type specimen, no. 4148, in Herb. Stanford University.

The plant is rare, and was collected at the same station where *Astragalus gaviotus* Elm. was discovered.

Deinandra simplex, n. sp.—Annual or at most biennial: stem brown, generally simple, chiefly branched toward the top, hispid pubescent; flowering branches ascending, leafy, the lower ones shortest, occasionally bearing subglomerate clusters below the terminal one: leaves ovate, lanceolate or linear-lanceolate, short hispid pubescent on both sides, more or less clasping at base, $1–5^{cm}$ long, the smaller

ones entire, the larger ones remotely dentate: heads turbinate, 8^{mm} long, upon leafy bracteate peduncles: 5 involucral bracts 6^{mm} long, uniserial, narrowly oblanceolate, the apex sparsely hispid pubescent, acuminate: *ray flowers:* ligulate corollas rarely more than three to each head, the basal tubular part 1^{mm} long, ovate, papillose; the expanded wing broadly obovate, 5^{mm} long, nearly that in width, yellow, the apex bearing a narrow middle tooth: achenes without pappus, 2^{mm} long, obovate, brown or possibly black when mature, puberulent, triquetrous, tightly enclosed by the involucral bracts; style slenderly 2-cleft, stigmatic on the edges for the entire length: *disk flowers:* the 5 disk flowers separated from the ray series by 5 united bracts: achenes short and sterile, bearing a paleaceous pappus 1.5^{mm} long: corolla tubular, 4^{mm} long, bearing 5 yellowish teeth: filaments half as long as anthers, separately inserted upon the corolla; anthers 2^{mm} long, with constricted triangular apices: style cleft, the lobes entirely ciliate.

Quite plentiful in dry half sandy soil, Santa Barbara, Santa Barbara county, California, August 1902. Type specimen, no. 3839, in Herb. Stanford University.

Machaeranthera pinosa, n. sp.—Densely tufted perennial, 1.5^{dm} high: underground stems numerously branched, those above ground rather rigid, brown, with a short cinereous pubescence, usually divaricately 3-branched from a little above the middle, basal portion marked with ring-like scars caused by the early falling of the radical leaves: basal leaves dry and brittle, those above the middle of the stem 3–5^{cm} long, linear-oblanceolate, densely cinereous pubescent on both sides, usually conduplicate above the middle, sessile though the lower half is narrow and petiole-like, minutely dentate, the teeth terminating in short and sharp-pointed hyaline spinules; upper leaves bract-like, broadest below the middle: heads turbinate, 1^{cm} high, solitary or upon bracteate brown glandular pubescent peduncles 4^{cm} long: involucral bracts imbricate, very unequal, mostly linear, acutely pointed, the exposed surface glandular, the inner surface straw-colored or purplish-blue: corolla of ray flowers 22^{mm} long, tube minutely pubescent, 12^{mm} long, gradually expanding into the rich purple-blue broadly spatulate minutely 3-toothed ligule: pappus in one series, 12^{mm} long, scabrous, reddish-brown, very unequal: corolla of disk flowers 0.75^{mm} long: stamens with anthers 3^{mm} long

and short filaments: style deeply cleft, the branches straight and with the entire dorsal surface stigmatic; immature achene 2^{mm} long, obovoid, finely pubescent.

Rather rare on the summit of Mt. Pinos, Ventura county, California, July 1902. Type specimen, no. 4145, in Herb. Stanford University.

This beautiful deep blue or purple-flowered Machaeranthera, like many other purely alpine plants, has the habit of apparently forcing its growth along crevices of rocky summits.

Chrysothamnus corymbosus, n. sp.—Shrubby, $0.5–1^{m}$ high, numerously branched, forming well rounded bushes; wood dry, soft, yellowish, with thin shredded bark: leaves on second year old branches of varying lengths, much shorter than on younger twigs, usually fascicled, soft pubescent on both sides, dry and becoming recurved; those on the upper branches mostly of the same length, $10–15^{cm}$ long, ascending, not fascicled, narrowly linear or oblanceolate, with a short sparse pubescence, the surface more or less glandular, obscurely punctiform: heads glomerated in rounded corymbs, $2–3^{cm}$ across, at ends of branches: peduncles 6^{mm} long or longer, they as well as the subtending bracts sparsely lanate pubescent, usually monocephalous: involucral bracts persistent, broad and mainly in two imbricate series; lower ones triangular, short and pubescent; upper ones 5^{mm} long, nearly glabrous and almost shining, broadly linear-obtuse, with narrow hyaline margins: heads about 7^{mm} high, cylindric or subturbinate, 10-flowered: ray flowers few, 8^{mm} long including the ciliate pubescent achene 2^{mm} long: pappus uniserial, 3^{mm} long, finely scabrous, whitish and copious: tubular part of the corolla shorter than the expanded portion, pubescent; ligule broadly elliptic, yellow, thin, apex much folding over, bluntly toothed: style cleft: corolla of fertile disk flowers tubular, 5^{mm} long, 5-segmented: filaments 3^{mm} long; anthers 2^{mm} long, linear, with triangularly constricted apices.

Near Lancaster, Los Angeles county, California, June 1902. Type specimen, no. 3668, in Herb. Stanford University.

During the middle or hottest part of the day this desert-loving plant gives off a very strong resinous odor.

Horkelia Rydbergii, n. sp.—Low prostrate perennial, forming dense mats: stems barely branching below the middle, the longer ones prostrate and ultimately erect or ascending, 2^{dm} long or less,

branching above the middle and bearing few-flowered cymes: leaves clustered at the base, longer ones 6^{cm} long, covered with a silky-velvety pubescence, usually with a petiole 2^{cm} long; stipules 15^{mm} long, adnate and conduplicate, the interior surface quite smooth, terminating in a laciniate pubescent segment 5^{mm} long; those of the smaller cauline leaves broader, larger lobed, and nearly clasping the stem; leaflets of the lower leaves 8–12 pairs, densely silky pubescent on both sides, 5^{mm} long, fully that in width, sessile, merely 3–5-pointed, the lower one or two pairs somewhat distant, those above the middle more or less crowded and diminishing in size toward the apex: inflorescence loosely cymose: flowers short or longer pedunculate, subtended by leaf-like bracts: hypanthium cup-shaped, 5^{mm} broad and 5^{mm} high including the teeth nearly 2^{mm} long; calyx bracts in two series of 5 segments each, the outer shorter and narrower, the inner 3^{mm} long and acute: stamens 10; filaments acuminate, nearly glabrous, 2^{mm} long and slightly unequal in length, petaloid in color, flattened especially toward the base; those opposite the petals much shorter than the others which are exceeded by the longer calyx segments; anthers 1^{mm} long, introrse and basifixed: petals alternating with the outer series of stamens, cuneate or oblong to obovate, 3–4^{mm} long, 2^{mm} wide, barely exceeding the longer of the calyx segments; between the base of filaments and receptacle proper a narrow dark-brown smooth circular band: receptacle ciliate, ovoid to conical: pistils smooth, numerous, sessile; style 3^{mm} long, erect, straight, constricted or articulated to the ovary; achenes 1^{mm} long, brown, semi-recurved.

Dry gravelly flat near Griffin's postoffice, Ventura county, California, July 1902. Type specimen, no. 3971, in Herb. Stanford University. Named in honor of P. A. RYDBERG.

Castilleia gleasoni, n. sp.—Perennial, 2–4^{dm} high, from a hollow thick dwarfed woody base: stems mainly from the base, branched at the middle, obscurely ridged or striate, clothed with a soft pilose pubescence which conceals the more or less dry glandular surface; branches usually clustered from the distal ends of the abruptly terminated stems, striate, similarly pubescent and glandular, bearing erect or sub-flexuose spicate racemes 1^{cm} long: leaves many but not crowded, all cauline and equally distributed; larger ones 4.5^{cm} long, 12^{cm} wide, 3–5-nerved, the pubescence on both sides concealing the

numerous fine sessile glands, the upper one-third divided into 3 lobes with the middle one usually broader and longer; smaller leaves linear to lanceolate and entire; axillary leaves few, short and inconspicuous, not fascicled: average bract 2^{cm} long, strongly 3-nerved, divided to below the middle into 3 strap-like purple-red entire segments; these are obtuse or rounded, glandular and pubescent especially on the outer surface above the middle: calyx tubular, 15^{mm} long, 4-nerved, glandular pubescent, the bilabiate part 5^{mm} long, each bearing acute teeth 2^{mm} long; galea 2^{cm} long, slightly curved, slit half way down, apex narrowly truncate or faintly 3-toothed, exterior apical section glandular, middle part pubescent, glabrous at base; lower lip represented merely by 3 broad and short lobe vestiges: stamens 4, the two inner ones slightly shorter; filaments separate, thread-like, inserted upon the corolla tube beneath the throat; anthers approximate, included by the galea, the two cells unequal in length, united above the middle, distinct below: style slender, gradually enlarging toward the apex, exceeding the galea by 2^{mm}, bearing a 2-lobed flattened stigma: capsule ascending, 15^{mm} long, ovoid to lanceoloid, slightly dorsiventrally compressed, acute or acuminate.

Cliffs and in rock crevices on the summit of Mt. Gleason, near Acton, Los Angeles county, California, June 1902. Type specimen, no. 3659, in Herb. Stanford University.

This "paint-brush" or "red-hot-poker," as I have heard it called, is neither the early flowering *C. foliolosa* H. & A. of the seacoast nor the glandular southern *C. Martini* Abrams.

Eriogonum baratum, n. sp.—Annual, $3–5^{dm}$ high, erect, mostly single: stems glaucescent, purplish at base, straight and erect, one-third the height of the plant, terete, of the same thickness throughout; branches 1–5 at a whorl, smooth and also glaucescent, ascending, ultimately widely branching, subtended by 3 acuminate smooth and coriaceous bracts $1–2^{mm}$ long: leaves all radical, longer ones 3^{cm} long, including the woolly petiole 2^{cm} long which is perceptibly expanded at base; blade proper 1^{cm} long, ovate to broadly elliptic or rotund, semi-cordate at base, upper surface glandular and woolly pubescent, lower deeply and densely lanate pubescent: flowers mostly axillary or terminal, always solitary upon slender purple-red drooping peduncles 1^{cm} long: involucre glaucous, often minutely glandular, coriaceous, $2–3^{mm}$ long, bearing five hyaline-margined obtuse teeth

from one-fourth to one-third the entire length of the involucre: pistillate flowers little protruding, the stalks apparently articulated, 2.5^{mm} long, commonly 10, becoming deflexed, intermixed with ciliate bristles 2^{mm} long: corolla 2^{mm} long, white or pinkish, petals 6, in two whorls; outer broad elliptic or more or less rectangular in shape, with bases clawed; inner shorter, narrower and obovate: staminate flowers fewer, sessile or sub-sessile, intermixed or more or less in the central region, also subtended by ciliate bristles, 1^{mm} long, petals smaller though similar in shape and equal in number: the 10 stamens included, upon slender filaments, bearing small yellow anthers: ovary smooth, elongated, 2^{mm} long, surrounded by numerous sterile filaments; styles 3, spreading, terminated by small capitate stigmas; achene sub-terete and spindle-shaped, purplish, smooth.

These hills contain borax mines, and since this plant is strictly confined to this region it would seem that the salt is a necessary constituent for it.

On very hot barren exposed round-topped hills between Griffin's postoffice and Mt. Pinos, Ventura county, California, July 1902. Type specimen, no. 3593, in Herb. Stanford University.

Lupinus glareosus, n. sp.—An almost acaulescent annual, 3–5^{dm} high, somewhat succulent though readily curing: stem very short, rather thick and hollow, terminated by a spicate inflorescence; branches with a soft short brownish pubescence, chiefly from the stem, the outer ones curved upward from the middle: leaves clustered at the point of branching, erect or ascending, upon finely pubescent petioles 1–5^{cm} long, with broadened bases subtended by laciniate adnate stipules; leaflets 10, sessile, only sparsely pubescent on both sides, soft and fleshy, obovate, on an average 15^{mm} long and 5^{mm} wide, the older ones with a very peculiar dead scarious upper margin: spikes cylindrical, 3^{cm} in diameter, 10–15^{cm} long, erect and exceeding the leaves, upon pedunculate scapes: flowers in whorls of 5, upon short pubescent pedicels, subtended by acuminate similarly pubescent bracts which slightly exceed it: calyx cup-shaped at base, bilabiate, pubescent; lower lip rather broad, 7^{mm} long, obtuse, 3-nerved; upper one thinner, 3^{mm} long, notched; banner broadly elliptic, 12^{mm} long, finely nerved and entirely glabrous; lateral wings equaling the length of the banner, nearly 5^{mm} in width throughout, basal margins ciliate and abruptly terminating into a short narrow claw; keel at least 12^{mm} long, falcate, with a constricted ring-like portion near

the base and with the margin of the aperture densely ciliate: stamens of two kinds; the 5 longer ones bearing small anthers, the shorter ones with linear anthers: style falcate, the stigmatic portion barely exceeding the keel; ovary covered with long rubiginous hairs; pod equally tapering to both ends, 1^{cm} long, 2-seeded, silky pubescent, terminated by a persistent much recurved style; seeds subsessile, smooth, compressed.

Griffin's postoffice, Ventura county, California, July, 1902. Type specimen, no. 3588, in Herb. Stanford University.

It is wholly confined to dry gravelly soil along water courses, hence its name.

Astragalus gaviotus, n. sp.—An erect densely tufted perennial $3–5^{dm}$ high: stems many from the woody base, branching above the middle, cinereous pubescent: lower leaves falling early, becoming recurved, 10^{cm} long, subtended by distinct acute triangular stipules 5^{mm} in length; leaflets extending nearly to the base, 7–15 remote and scattered pairs, $15–25^{mm}$ long, 5^{mm} wide, the rachis usually terminated by a solitary leaflet; lower ones strigulose and short-petioled, the larger and older ones broadly obtuse or truncate, linear to narrowly elliptic: racemose inflorescence $2–3^{cm}$ long, terminating the rigid striate and strigulose peduncles 10^{cm} long, barely exceeding the leaves: pedicels 5^{mm} long, ascending, strigose, subtended by shorter long acuminate strigulose bracts: calyx inflated, cup-shaped, 3^{mm} long, apex apiculate but often more or less toothed, barely pubescent with a mixture of black and whitish hairs: corolla, stamens, and pistils not seen: pod persistent, compressed, spreading or becoming pendent upon pubescent usually recurved pedicels 8^{mm} long, dull or yellowish-white, $6–10^{mm}$ wide, $20–28^{mm}$ long, gradually and acuminately tapering to both ends though more often widest above the middle, apex terminated by a short blunt cusp, the sides obscurely but finely reticulated and under a lens only sparsely hairy, straighter along the dorsal edge; seeds commonly 6, slenderly stipitate, flattened, smooth, brown, semi-reniform, strongly reticulated.

Sandy soil not distant from the beach at Gaviota, Santa Barbara county, California, May 1902. Type specimen, no. 3759, in Herb. Stanford University.

This plant is usually referred to *A. filipes* Torr., which however has a more northern and interior range and a more slender habit of branching.

ASTRAGALUS WHITNEYI **pinosus,** n. var.—A handsomely tufted and spreading variety of the alpine species, with many branches from

a perennial root; branches as well as leaves subtended by short, concrete, and scarious bracts or stipules: leaves ascending, usually 4^{cm} long, the lower one-fourth petiolate; leaflets glabrous or sparsely strigulose, 6–10^{m} long, 7–9 pairs though the lower ones are much scattering, the terminal either in pairs or solitary by abortion, subsessile, mostly conduplicate in the dried specimens, linear to lanceolate to oblanceolate: racemes terminal, 2^{cm} long, upon peduncles 4^{cm} long: calyx subinflated, 4^{mm} long, terminated by 5 short but narrowly sharp pointed teeth, short-pediceled, pubescence of black and whitish hairs: pod 3^{cm} long, obovoid inflated, narrowed toward the base but not stipitate, reflexed, glabrous, reticulations prominent, beautifully mottled with a purple or reddish-violet, falling rather early.

Summit of Mt. Pinos, Ventura county, California, July 1902. Type specimen, no. 4005, in Herb. Stanford University.

This variety is chiefly distinguished from the typical form by its scarious stipules, more linear leaflets, and in not being stringulose.

HERBARIUM OF STANFORD UNIVERSITY,
September 1903.

THE MORPHOLOGY OF MONASCUS PURPUREUS.*

EDGAR W. OLIVE.

BARKER'S account of the morphology and development of Monascus in the early part of 1903,[1] as will be remembered, was shortly afterward questioned in a contradictory paper by IKENO.[2] IKENO gave, in fact, a diametrically opposite interpretation of certain of the more important phenomena connected with the spore formation in this fungus, and even went so far as to assert positively that BARKER'S "Samsu" fungus did not belong to the genus Monascus. If BARKER is right, then Monascus shows close resemblances to other Ascomycetes; if, on the other hand, IKENO'S views are correct, the fungus is an aberrant form.

The main points of difference between these opposed views may be concisely stated as follows. BARKER maintains that sexual reproduction results in the formation of ascogenous hyphae. The ascogonium consists, according to him, of an elongated penultimate cell; while the original terminal cell, which is pushed over to one side by the growth of the enlarging ascogonium, constitutes an antheridial branch. Fusion takes place between the two, the elongated tip of the female cell functioning in this act as a kind of trichogyne. After fusion, this tip portion is cut off by a septum and its protoplasmic contents, as well as that of the antheridial branch, finally become disorganized and eventually disappear. It is the cut off penultimate cell of the ascogonial branch, called by BARKER the "central cell," which still further develops and produces the ascogenous hyphae. This central cell becomes enormously swollen and is invested at maturity almost completely by a mass of closely clasping sterile hyphae. During its enlargement and development it affords protection and nutriment to the growing ascogenous hyphae. The latter

*This work was done under a grant from the Carnegie Institution.

[1] BARKER, B. T. P., The morphology and development of the ascocarp in Monascus. Ann. Botany **17**:167–236. *pls. 12–13.* 1903.

[2] IKENO, S., Ueber die Sporenbildung und systematische stellung von *Monascus purpureus* Went. Ber. Deutsch. Bot. Gesell. **21**:259–269. *pl. 13.* 1903.

arise, according to the evidence obtained by this author, as an outgrowth of the swelling central cell, which grows over the surface of the latter, closely applied to it, until it finally pushes in, or invaginates, the enlarged central cell. In this invaginated cavity, or little "nest," thus produced, the ascogenous hyphae are formed, whether as buddings of the end of the in-pushing hypha, or simply as segments of it, the author does not make clear. At any rate, growth continues until the closely entwined hyphae occupy almost the whole of the interior of the enveloping perithecium. "Asci are eventually produced from the ascogenous hyphae, and in each of them eight ascospores are produced. When the spores are ripe, the asci and ascogenous branches degenerate, the surrounding central cell having by this time lost its contents, remaining as a brown cuticularized enclosing wall. The spores are thus liberated into the cavity enclosed by this wall, and the ripe perithecium appears to be nothing more than a brown cuticularized sporangium-like structure." (*L. c.*, p. 204.)

IKENO apparently agrees with BARKER in regard to sexual reproduction in Monascus, although his evidence appears to be drawn from dubious sections, judging from his one drawing of the process. IKENO's main point of dispute with BARKER lies, however, in the method of spore-formation. He asserts that there are no ascogenous hyphae in the Monascus which he studied, but that, on the other hand, so-called "spore mother-cells" arise by free cell formation. The cytoplasm of the ascogonium becomes, according to him, aggregated about certain nuclei, resulting in the formation of uninucleate "Cytoplasmaballen," or "spore mother-cells." According to BARKER's account, these "spore mother-cells" are segments of a hypha, which become rounded up into asci. IKENO further notes that the "Cytoplasmaballen" become increased in number by fission, and that they may contain, at the culmination of nuclear division, a greater number of nuclei than is necessary for spore-formation, and he says that the extra ones degenerate. Usually six or eight spores are finally produced, which are, in his opinion, formed by free cells formation, leaving a small amount of epiplasm between and surrounding the spores, thus corresponding to conditions observed in the ascus. An agreement is noted in the final phenomena connected with the development of the fungus, in that in the mature spore fruit

the walls of the "spore mother-cells" become disorganized, thus setting free the spores within the perithecial wall. IKENO concludes with the assertion that WENT'S classification of Monascus among the Hemiasci is strictly correct, and that BARKER'S fungus is not a member of the genus Monascus, but that it is a typical Ascomycete.

Several important differences will be at once noted in these two accounts, the crucial difference being the one which concerns the origin of certain structures in the swollen ascogonial cell, or "central cell," as BARKER terms it. IKENO conceives of these structures, the "Cytoplasmaballen," as arising by free cell formation, simply by an aggregation of cytoplasm around certain nuclei; other nuclei in the ascogonium taking no part whatever in the process. BARKER, on the other hand, thinks that these deeply staining bodies are segments of one or more hyphae which have grown in from the outside of the central cell, and that the ultimate origin of these ascogenous hyphae is as outgrowths of the central cell itself, which finally turn and grow again into the cell from which they have sprung. Both assert that these bodies bear within them later the spores, and in other respects the two accounts in the main agree.

DANGEARD proposes now to assist us out of our difficulties by making BARKER'S Monascus a new species. KUYPER,[3] the latest writer on the subject, accepts this suggestion, and in a study of both *M. purpureus* Went and *M. Barkeri* Dang., finds confirmation in the main of IKENO'S conclusions, although he calls IKENO'S "spore mother-cells" true asci. He adds, however, the additional observation that a nuclear fusion precedes the development of the young asci. *Monascus Barkeri* differs, according to his views, from *M. purpureus* in an important respect. In *M. Barkeri* he has the nuclei fusing in pairs *before* the formation of the asci, and in *M. purpureus*, *after* the asci are formed. In *M. Barkeri*, his observation agrees, therefore, with BARKER'S assumption that nuclear fusion in pairs occurs in the enlarging ascogonium. KUYPER regards this fusion as analogous to the fusion in the young ascus of *M. purpureus*, but such a fusion as he describes in the latter should be referred rather to the later

[3] KUYPER, H. P., De peritheciumontwikkeling van *Monascus purpureus* Went en *Monascus Barkeri* Dang. Kon. Akad. van Wetenschappen, Amsterdam **13**:46–294. *1 pl.* 1904.

fusion which is known to occur in the young asci, whereas his fusions in *M. Barkeri* belong to the early sexual fusions, as are seen in Pyronema and other forms.

As BARKER and others have pointed out, the development of Monascus from the germination of the ascospores or the conidia up to the formation of the fructifications may be readily followed out in hanging drop cultures. Observations of living cultures of Monascus in hanging drops show that a fusion appears to take place between the basal cell of the antheridial branch and the tip portion of the ascogonial branch, which BARKER likens to a trichogyne. It appears likely that in some cases, at least, this fusion takes place after the cutting off of the tip of the ascogonium, although BARKER asserts that the act must take place before the wall is thrown across. The swelling up of the central cell and later an appearance which suggests the pushing in or invagination of the swollen central cell by some body which enters generally near the side on which the stalk is seen; further, the enlargement of this invaginated part until the central cell seems to be entirely displaced by it; and, finally, the appearance of vacuole-like bodies within the invaginated cavity and the final formation of spores, which adhere for a time in little groups, all may be readily traced in hanging drop cultures.

When one attempts to explain these appearances, however, by an examination of sections, one meets with many difficulties, as is evidenced by the remarkable differences obtained by the investigators above mentioned. I have seen in but few instances, in fact, a hypha-like outgrowth from the central cell, and, perhaps somewhat less rarely, the actual pushing in of a hypha-like body into the side of the central cell, thus forming the "nest," or invaginated cavity, in which the ascogenous hyphae develop. Another theory than that held by BARKER has suggested itself to the writer, which is borne out by many observations. Instead of the ascogenous hypha arising from the central cell, it may have its origin in the "trichogyne-like" end of the ascogonial branch. The following observations point to this conclusion. First, the rarity of protuberances from the central cell which are long enough to furnish absolute conviction that the outgrowth is a hyphal branch. They may as well be, as BARKER himself intimates, a bulging out of the swelling central

cell at a point where the investment formed by the covering hyphae is incomplete. Secondly, the fact that, in very thick sections, one sometimes finds that the invaginated cavity of the central cell is connected with the outside by a comparatively large, broad opening, where we might naturally expect a small, narrow one, since the ascogenous hyphae are relatively small. The large opening suggests the pushing in of a larger body, possibly the fertilized "trichogyne" cell above mentioned. Lastly, the frequency of occurrence in early stages of a comparatively large, deeply staining cell, lying to one side of the swollen central cell and not yet pressed into it, indicates that this deeply staining body is not a hypha with the origin BARKER attributes to it, but is instead the cell above mentioned. Should this prove true, then the fertilized ascogonial cell is in reality the end cell, while the enormously swollen penultimate cell performs a sort of "nurse-cell" function, ultimately becoming entirely displaced, its contents digested and absorbed, by the ascogenous hyphae developing within it.

That the structures growing within the cavity in the central cell are segments of ascogenous hyphae, I have no doubt; therein I agree perfectly with BARKER. For one may see in sections of almost every immature fructification young segments which are elongated and twisted and hypha-like, and which sometimes show evidences of dividing by fission, as is pointed out by IKENO. Later, these segments become rounded off and vacuoles appear in them; still further development results in the formation of their eight spores.

The Monascus species which I have used was first sent from Java some years ago by D. G. FAIRCHILD to ERWIN F. SMITH and was regarded by the latter as *M. purpureus* Went. Professor HARPER, who in turn received some material from Dr. SMITH, has turned the fungus over to me for examination. So far as I am able to judge from gross measurements, and from a careful comparison of figures, this form agrees with BARKER's description of his Monascus, and as well with the accounts of WENT, UYEDA, and others, so that my opinion is that IKENO and BARKER worked with similar forms. I find therefore in the main a confirmation of the conclusions of BARKER, as well as satisfactory explanations of the misinterpretations of IKENO.

MADISON, WIS.

BRIEFER ARTICLES.

FERTILIZATION IN THE SAPROLEGNIALES.

TROW[1] has reaffirmed his conviction that a sexual act is present in the water molds. His paper gives in detail the results of an investigation of *Achlya DeBaryana* and *A. polyandra* in comparison with my own study of oogenesis in Saprolegnia.[2] Much of his paper is devoted to a defense of his earlier work and to sharp criticisms of the skepticism of myself and others.

A priori there is of course no reason why the Saprolegniales should not show examples of sexuality; the discussion has only been on the evidence that TROW presented in his paper of 1899.[3] This evidence consisted in the varying number of nuclei present in the oosphere and oospore, expressed by TROW in the ratio 1:2:1, and certain figures of male gamete nuclei within the egg which did not seem to me clear enough to be convincing and appeared capable of other interpretations. I found that binucleate eggs, young and old, were "quite common" in an apandrous form of *Saprolegnia mixta*, and that by the methods of oogenesis bi- and trinucleate eggs might be expected in any of the Saprolegniales. Indeed all investigators of this group, HUMPHREY, HARTOG, and TROW himself, have known and described binucleate eggs. TROW in his last paper (p. 547) refers to the binucleate eggs of my form as of "occasional occurrence" and "in all probability of a pathological character." I stated expressly that they were "quite common" and I cannot see the slightest reason for suspecting them to be pathological. The cultures appeared perfectly healthy and the phenomenon was not infrequent as TROW implies. For these reasons I held that the number of nuclei in the ratio of 1:2:1, ordinarily accepted as evidence of fertilization when found successively in young and older stages of eggs and oospores, was insufficient for the establishment of sexuality in the Saprolegniales. To my mind proof is only furnished by clear and unmistakable instances of fusion between eggs and antheridial filaments and with the male nuclei actually *en route* to the female at the point

[1] TROW, A. H., On fertilization in the Saprolegnieae. Ann. Botany **18**: 541–569. *pls. 34–36.* 1904.

[2] DAVIS, B. M., BOT. GAZETTE **35**: 233. 1903.

[3] TROW, A. H., Ann. Botany **13**: 131. 1899.

of fusion and within the egg. Few botanists would have been satisfied I think with TROW's evidence on the latter point in his paper of 1899. I regarded his views as "unproven and improbable" in the face of the mass of observations upon which most botanists have generally agreed that the Saprolegniales were apogamous. I still consider myself quite justified in taking this attitude, which I tried to present with due consideration to TROW as possibly being mistaken in his interpretation of some very difficult conditions. He seems to have taken my expressions as controversial, which I tried hard to guard against, and has certainly answered them in that spirit. One result at least has been an account of fertilization in *Achlya DeBaryana* which in detail of description and clearness of figures is quite a different sort of contribution from that of 1899.

Achlya DeBaryana furnished TROW the most complete series of stages of fertilization. In his *figs. 23–26* the antheridial filaments are united with the eggs by broad strands of protoplasm, and nuclei lie in some cases almost exactly at the points of fusion, either as though they had just entered the egg or were about to do so (*fig. 23*). The figures (especially *24* and *25*) even show that peculiar structure of the protoplasm which indicates a flow from the antheridial filaments into the eggs, conditions which have been illustrated many times in accounts of fertilization among the Peronosporales. These statements give us what we have a right to expect of any account of fertilization, and especially when the technical conditions are so complicated as in the Saprolegniales. They seem to me fundamental to the present problem, and the establishment of the ratio of nuclei in oosphere and oospore as 1:2:1 merely a corollary to the main proposition. If TROW will exhibit his preparation showing these protoplasmic fusions of antheridial filaments with eggs at scientific meetings in Great Britain or elsewhere he is not likely to have any difficulty in establishing his contention.

Of greater interest to me than the evidence of fertilization is TROW's account of a second mitosis in the oogonium and the origin of the aster-like structures which I discovered in Saprolegnia and considered coenocentra. During the second mitosis, according to TROW, two centrosomes with radiations appear at the poles of the spindle in anaphase, structures which were not present in the first mitosis. Some of these increase rapidly in size and become the centers of the egg origins, each one being accompanied by the nucleus that lay beside it, after anaphase of the second mitosis. Relatively few of the nuclei in the oogonium pass through this second mitosis, the remainder degenerating, and TROW believes that some of the daughter nuclei of this division with their asters also break down. The

surviving asters with their accompanying nuclei become the centers around which the cleavage of the protoplasm proceeds to form the eggs. TROW calls the egg-asters "ovicentra." He believes that the number of chromosomes shown in the first mitosis is reduced by half to form four in the second, so that the latter is a reduction division in oogenesis.

TROW'S account of the development of his ovicentra is fundamentally different from mine. I regarded them as simply representing dynamic centers of the protoplasm without any relation to mitotic phenomena, centrosomes, or asters, and as strictly comparable to the coenocentra of the Peronosporales. TROW considers them centrosomes in an aster (astrospheres) appearing at a final reduction division (second mitosis) in the oogonium. The situation has become very much complicated. If ovicentra are the same as coenocentra, why have not the latter been found associated with mitotic figures in the Peronosporales, where the structures are large and have been much studied? Is it possible that we have a new structure in the Saprolegniales? I am not willing to give up my view of oogenesis, although I can at once see the necessity of further investigation in both the Saprolegniales and Peronosporales. I do not think that TROW has presented enough evidence or treated the subject sufficiently with reference to the Peronosporales to be convincing. His theory is based, so I understand, chiefly upon the sections from one oogonium. There are some interesting questions suggested by the group of figures numbered *18*, which one hesitates to ask without seeing TROW'S preparations. But why are not the asters present at metaphase, the time when such structures are generally most conspicuous? And again, why are the asters sometimes so far away from the poles at anaphase (*fig.* 18^8)? Is it possible that the "anaphase" is simply a resting nucleus drawn out towards a coenocentrum and attracted by it, as is the habit in the Peronosporales? These questions are not put in a captious spirit, but by one who is deeply interested in the problem and knows the difficulty of the investigations. TROW has advanced a most interesting hypothesis, which he must expect to be keenly scrutinized.

"The sperm nucleus soon after its entry into the oosphere acquires a distinct centrosome and astrosphere." This seems to the writer the most remarkable announcement in TROW'S paper. Neither the origin nor the fate of this structure was followed. It looks exactly like an ovicentrum. The male and female nuclei and their accompanying astrospheres remain quite apart in the egg until the astrospheres disappear. In the meantime the oospore gradually fills with reserve material and the wall thickens. While these processes are under way the gamete nuclei fuse. The structure

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of the egg when it contains two astrospheres with the gamete nuclei is of great interest, and this phase of the subject is worthy of extended study. I have seen and figured eggs in Saprolegnia with two coenocentra, each accompanied by a nucleus, when it was evident that the two were sister structures included within the same egg origin.

It is evident that very much more work must be done both in the Saprolegniales and Peronosporales before some of the points suggested by TROW'S paper will be established. An ovicentrum arising from an aster associated with a reduction mitosis is a very different sort of conception from our present idea of the coenocentrum in the Peronosporales. The same sort of structure is also reported to appear suddenly beside the sperm nucleus after its entrance into the oogonium. It seems hardly conceivable that similar structures could behave in such different ways or could hold relationships to the coenocentra of the Peronosporales. Of course my own view of the essential agreement of the Saprolegniales and Peronosporales in processes of oogenesis around coenocentra must await the results of future investigations.—B. M. DAVIS, *The University of Chicago.*

THE SEXUAL ORGANS AND SPOROPHYTE GENERATION OF THE RHODOPHYCEAE.

OLTMANNS'S theory that the structure developed from the fertilized carpogonium in the Rhodophyceae represents a sporophyte generation has received substantial confirmation in recent cell studies of WOLFE[1] on Nemalion. This investigation also makes an important contribution to our knowledge of the sexual organs of the red algae, establishing some complications of structure that are likely to prove very general in the group, and quite changes our conception of their morphology. Their possible relations to the sexual organs of the lichens, Laboulbeniaceae, and even to the Uredineae is full of interest.

The trichogyne of Nemalion contains a well defined nucleus which appears shortly after this structure begins to push upward from the carpogonium, but is only found in a fragmented condition in the mature trichogyne. The egg nucleus, which lies above the chromatophore in the carpogonium during the early development of the trichogyne, passes later to the bottom of the carpogonium. Although no mitotic figure was observed it seems clear that the nuclei of the trichogyne and egg are sisters, following a division in the terminal cell of the procarp.

These observations on Nemalion confirm my account of the trichogyne

[1] WOLFE, J. J., Cytological studies on Nemalion. Ann. Botany **18**:607–630. *pls. 40–41.* 1904.

of Batrachospermum,[2] which I described as a nucleated cell with a chromatophore, and whose long life was accounted for by these complexities of structure. Later investigators, SCHMIDLE[3] and OSTERHOUT,[4] failed to find the trichogyne nucleus, but I am confident that my account of this structure is substantially correct. It is probable that nucleated trichogynes will be discovered in other red algae, and indeed they are likely to be quite general in the group, for the great length of these structures is much more readily understood as nucleated appendages than as cytoplasmic extensions from the small carpogonia. We shall have to recast our conception of the female sexual organ of the red algae. Instead of being a uninucleate cell (oocyst) with a filamentous cytoplasmic receptive outgrowth, we shall probably have at least a two-nucleate structure with the trichogyne obviously very much like a second cell in the organ.

These complications, puzzling at first thought, may clear up some very difficult problems of morphology. I refer to the multicellular trichogynes of the lichens and Laboulbeniaceae. They will not seem to be so far removed from the female organs of the red algae if trichogyne nuclei prove to be general, and we may come to regard them as the highest expressions of this growth tendency on the part of a primitive type of unicellular organ. BLACKMAN'S[5] recent investigations in the Uredinales indicate that female sexual organs are present in some forms (e. g., Phragmidium), and the presence of a sterile cell above the fertile is wonderfully suggestive of a trichogyne. All the female organs with multicellular trichogynes form a group quite by themselves, and apparently without relation to other multicellular sexual organs (gametangia). Since the cells are probably connected with one another by broad strands of cytoplasm, the physiological conditions may be very close to those of multinucleate sexual organs (coenogametes).

The sperm (spermatium) of Nemalion is formed singly in the spermatocyst and leaves this structure as a uninucleate naked or thin-walled mass of protoplasm. But before fertilization the original nucleus of the sperm divides with a mitotic figure, so that two male nuclei are formed and both enter the trichogyne. SCHMIDLE reported binucleate sperms in Batrachospermum, and some of my own figures show the same conditions, which, however, I explained as phenomena of fragmentation. It is evident that the sperm discharged from the spermatocyst (antheridium)

[2] DAVIS, B. M., Ann. Botany **10**: 49. 1896.

[3] SCHMIDLE, Bot. Zeit. **57**: 125. 1899.

[4] OSTERHOUT, Flora **87**: 109. 1900.

[5] BLACKMAN, Ann. Botany **18**: 323. 1904.

involves all of the protoplasm of this mother-cell, and the mitosis is a relic of times when more than one sperm was formed. The present binucleate sperm is a simple type of multinucleate gamete (coenogamete).

Both male nuclei are discharged into the trichogyne of Nemalion, which at the time of fertilization contains no organized nucleus. One male nucleus passes into the carpogonium, in the upper portion of which it meets the female nucleus and here fusion takes place. Several sperms may unite with and discharge their contents into the trichogyne, but supernumerary male nuclei soon break down. The fertilization of Batrachospermum undoubtedly takes place in essentially the same manner as described by SCHMIDLE and OSTERHOUT, but both of these observers failed to understand the complications of the trichogyne. On the other hand, I was misled by these complications and failed to discover the essential act of fertilization as a nuclear fusion in the carpogonium.

The development of the cluster of fertile filaments (gonimoblasts) follows the older accounts, but WOLFE contributes a new point of importance in showing that the carpospores are developed successively at the ends of the filaments. When one spore has been discharged the cell behind grows into the old cavity and develops there a new carpospore. This method of spore formation by successive proliferations is well known in certain groups of fungi, but among the algae has so far only been described for the Rhodophyceae.

The cytological evidence that the cystocarp is a sporophyte generation rests with a count of the chromosomes in mitotic figures at different periods of the life history. The number is about eight for the gametophyte, as shown in vegetative mitoses and during spermatogenesis. Mitotic figures were easily found at certain stages in the development of the fertile filaments (sporophytic), and these always presented an approximate double number of chromosomes, about sixteen. The numerical reduction of the chromosomes seems to take place just previous to spore-formation, for nuclear figures in the terminal cell of the older fertile filaments had quite the same appearance as those of the gametophyte and showed eight chromosomes. The manner of the reduction was not determined.

WOLFE gives some interesting details of cell and nuclear structure. The chromatophore of Nemalion has the form of a hollow ellipsoid, the center being a vacuole and not a pyrenoid. The chromatin of the resting nucleus is present in the form of a globular body (nucleolus). During prophase the chromatin passes along fibrillae to the nuclear wall. The spindle is intranuclear and centrosomes are present at its poles during metaphase.—B. M. DAVIS, *The University of Chicago.*

CURRENT LITERATURE.

BOOK REVIEWS.

The life history of Pinus.

DR. FERGUSON'S detailed account of this subject, profusely illustrated with excellent figures, will be useful as a reference work.[1] Much of the text and many of the figures have been taken from her previous papers, but the investigations have been pushed farther in every direction, so that the repetition adds to the value of the present account. The work deals primarily with *Pinus Strobus*, but conclusions are in most cases supported by observations upon several other species.

The titles of the five chapters are: microsporogenesis, the male gametophyte, macrosporogenesis, the female gametophyte, fertilization and related phenomena. In the appendix, several abnormal conditions are described.

In most species the archesporium is well developed before the approach of winter, but the mother-cell stage is not reached until the following April; in *P. Strobus* the archesporium does not appear until May. Probably there is a qualitative reduction of chromatin during the second mitosis in the pollen mother-cell. The air sacs arise by the separation of the exine from the intine at two definite points. A partial wall, lying within the intine at the prothallial end of the spore, is an interesting feature not hitherto described. The body cell ("generative cell") is not surrounded by a definite wall, and when its nucleus divides the two sperm nuclei lie free in a common mass of cytoplasm, never organizing distinct sperm cells. The two sperm nuclei are unequal in size and the larger one is always in advance.

The endosperm contains about two thousand free nuclei before walls begin to be formed. The archegonia appear about two weeks before fertilization. The independence of the male and female chromatin during fertilization, described by Miss FERGUSON and previous investigators, is here worked out in great detail. No cell walls are laid down at the base of the oosphere until the eight-nucleate stage of the proembryo has been reached. The divisions which result in the formation of four tiers of cells in the proembryo are described as taking place in the upper nuclei, which lie in the cytoplasm of the main body of the egg.

Miss FERGUSON'S conclusions are based upon an adequate field study and upon the examination of an immense number of preparations, so that the danger

[1] FERGUSON, MARGARET C., Contributions to the life history of Pinus, with special reference to sporogenesis, the development of the gametophytes, and fertilization. Proc. Wash. Acad. Sci. **6**: 1–202. *pls. 1–24.* 1904.

of describing an occasional condition as a typical one has been reduced to a minimum.

It is due to Miss FERGUSON to announce that the manuscript left her hands Dec. 29, 1902, after which only a few minor corrections in the latter part o the work were possible.—C. J. CHAMBERLAIN.

MINOR NOTICES.

THE FIRST PART of the second supplement (1896–1900) of the Kew Index, containing the letters A–L, is ready for distribution. It is printed uniformly in all respects with the *Index Kewensis* itself. The advantage of having such a record of the years 1896–1900 cannot be overstated, and the tremendous amount of labor it involves on the part of Sir W. T. THISELTON-DYER and his colleagues deserves recognition from botanists. The American Branch of the Clarendon Press is at 91–93 Fifth Avenue, New York City; and the price of the part is 13s.—J. M. C.

KOORDERS and VALETON[2] have published another fascicle of additions to the known arboreal flora of Java. The five families included are Fagaceae (Castanea 3 spp., Quercus 25 spp.), Lauraceae (71 spp., 10 of which are new), Monimiaceae (4 spp.), Coniferales (Podocarpus 5 spp., one new), and Casuarinaceae (2 spp.).—J. M. C.

NOTES FOR STUDENTS.

INSECTS AND FLOWER COLORS.—Before considering some very recent papers on this subject, brief reference may be made to the work of PLATEAU, who more than any other investigator, has raised objections to the familiar "flag" or "signal" theory, as held by SPRENGEL, MUELLER, and DARWIN. Among the more striking of PLATEAU'S observations,[3] we may note that he observed insect visits in normal number to heads of Dahlia, which were variously hidden from vision by means of leaves and papers; that the removal of the corolla from Lobelia flowers did not affect the insect visits, as claimed by DARWIN; that insects visit indifferently flowers of Salvia and Zinnia, similar in species but differing in color; that Pelargonium, however showy the flowers, is but little visited by insects normally, but that visits are readily induced in great numbers, if honey is placed on the flowers; that visits to Dahlia flowers cease if the nectar glands are removed, but begin again if honey is added; that the removal of the outer radiant flowers of Hydrangea has no effect on insect visits; that even such intelligent insects as bees commit many errors, visiting buds, wilted flowers, fruits, etc. In general

[2] KOORDERS, S. H., and VALETON, TH., Boomsoorten op Java. Bijdrage no. 10. Mededeel. 'sLands Plant. no. 68. pp. vi + 287. Batavia. 1904.

[3] See Bull. Roy. Acad. Belg., 1895, 1896, 1897; Mém. Soc. Zool. France, 1898, 1899, 1900; Ann. Soc. Entomol. Belg. 1901, 1902; Bull. Roy. Acad. Belg. 1902. Reviews of these articles in Biol. Cent. **16**:417; **17**:599; **18**:469; **19**:349; **20**:490; **21**:650; **23**:224; **23**:311.

it appears that PLATEAU'S views have become less positive; he held at first that color and form have no influence in attracting insects to flowers. At present, while all color preference is denied, and while odor and the presence of nectar are believed to be the most potent attractive agents, he seems not to deny altogether the possibility of color attraction. PLATEAU'S work has been accepted by but few students of flower ecology, and has been violently attacked especially by KIENITZ-GERLOFF.[4] PÉREZ,[5] while not calling PLATEAU'S results in question, thinks that his conclusions are too one-sided. He holds that odor attracts at a distance, but that color serves to give directional precision close at hand. FOREL[6] thinks that PLATEAU and other authors have given insufficient attention to the memory sense of insects.

The immediate occasion for this review is the work of ANDREAE[7] and GILTAY.[8] ANDREAE begins his admirable treatise with the rather teleological statement that it is inconceivable that there should be so many showy flowers in the world, unless they are of some value to the plant, and that we cannot conceive of any use other than the attraction of insects! As the result of a great many ingenious experiments, he divides insects into two general groups: those with weak visual sense, short flight, and high odor sense; and those with opposite characters. The former group embraces lower forms for the most part, while the latter group, in particular, includes the Apidae and the higher Diptera. Thus, while many insects are attracted chiefly by odor, the bees and the higher flies are attracted chiefly by color. Bees tried to get inside of inverted glass vessels with flowers inside, while they paid little attention to open vessels with honey or perfume. A very gaudy artificial poppy had more visits than natural and less showy flowers, although it was observed that the insects soon learned to visit non-showy flowers containing honey and to avoid showy flowers that had no honey. Since the perception of odor is highly modified by direction of wind, moisture, and the presence of other odors, ANDREAE thinks that color is a much more reliable and effective attractive agent than odor.

The memory sense, touched upon by FOREL and ANDREAE, has been the special thesis for GILTAY'S work, and his work seems to harmonize the discordant results of PLATEAU and ANDREAE. A new line of experimentation is suggested by his work on *Papaver Rhoeas*, a species whose flowers are self-sterile; from one group the petals were removed and the flowers left free for insect visitation, another group was left in the normal condition and free for insect visitation,

[4] See Bot. Zeit. **54**:123; **55**:84; **55**:108; **56**:138; Biol. Cent. **18**:417; **23**:557.

[5] See Act. Linn. Soc. Bordeaux, 1896; Mém. Soc. Sci. Phys. Nat. Bordeaux, 1903.

[6] See Zool. Jahresb. 1901.

[7] ANDREAE, E., Inwiefern werden Insekten durch Farbe und Duft der Blumen angezogen? Beihefte Bot. Cent. **15**:427–470. 1903.

[8] GILTAY, E.: Ueber die Bedeutung der Krone bei den Blüten und über das Farbenunterscheidungsvermögen der Insekten. I. Jahrb. Wiss. Bot. **40**:368–402. 1904.

while a third group had the corollas removed and was hand-pollinated. Instead of noting insect visits, the seeds from an equal number of flowers of the three groups were weighed. The average for each fruit was 117^{mg} in normal insect-visited flowers, 115^{mg} in the hand-pollinated flowers deprived of corollas, and but 50^{mg} in the flowers deprived of corollas, which were left free for insect visitation. In other words a poppy with showy flowers produces more than twice as much seed as a poppy without showy flowers, when left free to insect visits. Thus GILTAY was at first led to doubt PLATEAU'S conclusions. However, further experiments produced a modification of his views, since it was noted that insects, and particularly bees, pay less and less attention each day to showy flower groups where no nectar is present, while they pay more and more attention each day to inconspicuous flower groups, where nectar is present. It would seem, then, that PLATEAU failed to see the earlier visits of his insects, or at least failed to discriminate in his results between the earlier and later visits, while ANDREAE, in general, seems to have concluded his experiments too soon.—H. C. COWLES.

SCHMIDT[9] defines the mangrove association as that made up of tree-like evergreen plants which live near the strand of sea and estuary where the ground is constantly or at regular intervals flooded with salt or brackish water. Owing to its peculiar development and mode of life this is the most characteristic and well defined association known. The English "tidal forest" or the Holland "vlordborsch" is suggested as preferable to mangrove association, the former expressing exactly what is characteristic of the formation. The Barringtonia association (Schimper) borders closely upon the mangrove. As a rule, however, they are quite distinct, the Barringtonia being found on a higher level where the tidal water does not reach.

Light plays an important part in determining the position of the leaves and branches. By placing ten leaves horizontal and ten others upright in the normal light of the mangrove forest it was found that disorganization of the chlorophyll took place in one-half to two minutes in the former, while after thirty minutes only a partial disorganization occurred in the latter. By assuming the vertical position the buds and leaves expose the least surface to the direct rays of the sun. The relative intensity of the light according to the exposure of photographic paper is for the open sea one-fourth to one-half second, in the mangrove two seconds, and in the inland jungle ninety seconds. Hence it is seen that the light is very intense in the mangrove swamp. In the inland jungle the undergrowth does not arrange its leaves so as to get the least light, but so as to get the most, *i. e.*, in a horizontal position.

The major part of the article is devoted to taxonomic descriptions, emphasis being laid upon the arrangement and character of the buds, branches, and leaves.

[9] SCHMIDT, JOHS., Bidrag til Kundskab om Skuddene hos den gamle Verdens Mangrovetræer. (Contribution to the knowledge of the shoots of mangroves in the old world.) Bot. Tidsskrift **26**: 1–113. *figs. 46.* 1904.

No general uniformity exists in regard to the branching, although two general types may be separated: (1) the cymose, (2) the racemose. The leaves show considerable similarity in outline. Two type groups are made, the narrow leaved and the broad leaved type. The former type occurs only on species whose leaf-bearing branches are short and upright, while the broad leaves occur only on those whose branches are long.

In regard to protection of buds there is a considerable uniformity. Rhizophora, Bruguiera, Ceriops, Kandelia, and Scyphiphora are protected by means of axillary leaves which surround the developing parts; Aegiceras and Xylocarpus by means of true bud scales; Lumnitzera by red fleshy bud scales; Avicennia and Sonneratia by means of depressions in the leaf stalks. In comparison with northern trees, therefore, it will be seen that the majority of mangroves have buds similar to summer buds (Platanus), while Aegiceras and Xylocarpus correspond in this respect to the winter buds of northern latitudes.

The author criticises ARESCHOUG's work on the anatomy of mangrove leaves,[10] in that the latter author has not studied the plants in nature and his theory that salt-secreting hydathodes are general among mangroves is not proven in nature. That salt-secreting glands do occur is definitely proven, but only in the one genus Aegiceras.—G. H. JENSEN.

THE FINAL paper of BLACKMAN's studies on the fertilization, alternation of generations, and general cytology of the Uredineae has appeared,[11] presenting the subject more fully than the preliminary account which was reviewed in our April number.[12] We shall note at this time simply some additional details in this very clear and interesting paper.

The structure of the nuclei and processes of mitosis were studied, but it is evident that these subjects are very difficult. The chromatin remains for the most part in masses, so that chromosomes cannot be counted; but of course while there is but one mass throughout the gametophyte history from the teleutospore to the aecidium, there are two in the paired nuclei of the sporophyte. The nucleolus, always present, is extruded with each mitosis and formed anew in the daughter nuclei. A rudimentary spindle can sometimes be observed, with bodies at the poles which BLACKMAN calls centrosomes and which he believes arise by division, but his evidence seems insufficient on the latter point. The "conjugate" method of division of the paired nuclei only differs from that of single nuclei in the fact that two divide simultaneously side by side. The daughter nuclei remain entirely apart, so that the continuity of the chromatic material is not broken until the fusion in the teleutospore.

BLACKMAN points out the exact agreement of certain conditions in the Basidiomycetes with those in the Uredinales. Thus the mycelium preceding the basidium

[10] Bibliotheca Botanica, heft 56.

[11] BLACKMAN, V. H., On the fertilization, alternation of generations, and general cytology of the Uredineae. Ann. Botany **18**: 323–373. *pls. 21–24.* 1904

[12] BOT. GAZ. **37**: 320. 1904.

contains paired nuclei, which by fusion form a single nucleus in the mature basidium; the basidiospores are of course uninucleate, as is the mycelium that arises directly from them. Somewhere in the history of the mycelium the single nuclei must become paired. This will correspond exactly to the period of the aecidium in the life history of a rust, and must represent the time when an ancestral gametophyte developed sexual organs, now suppressed, and passed over to a sporophyte generation. The paired nuclei probably arise, as in the rust, by the union of neighboring cells in the mycelium, a process of apogamy, at the period when the sexuality is due.

It is important to note that the simpler types of life histories in the Uredinales where an aecidium is omitted must be regarded as derived from the *eu* and *opsis* forms by the entire suppression of cells which represent female sexual organs, and such life histories are in essential agreement with those of the Basidiomycetes which stand at the extreme in the process of reduction.—B. M. DAVIS.

JULES LAURENT[13] has given a detailed account of his experiments on the carbon nutrition of green plants. While the old humus theory was long ago abandoned, largely by reason of the work of LIEBIG, the tendency in recent years has been to hold to the utilization of organic foods to some extent, at least, by normal autotrophic plants. BÖHM, E. LAURENT, and ACTON have conducted rather conclusive experiments along this line, and a moderate amount of heterotrophic nutrition on the part of autotrophic plants is accepted by PFEFFER and JOST. The most conclusive experiments upon which this view may be based are those here considered, whose publication in full has been long awaited, since a preliminary notice was published in the Comptes Rendus for 1898. The chief reason for reposing confidence in LAURENT'S work is because he has worked with aseptic media, according to the most approved modern technique. Experiments with maize roots in contact with glucose solutions, in addition to DETMER'S solution, resulted in an increase of dry weight in the dark, whereas control cultures in DETMER'S solution only failed to show such increase in weight. MAZÉ has secured a like result with the vetch. Cultures in an atmosphere deprived of CO_2, but exposed to light showed an increase of weight due to an intake of glucose by the roots. Various plant species, previously deprived of starch, whose roots were placed in 1 to 5 per cent. glucose solutions, the plants being placed under a bell-jar, over a potash solution and exposed to sunlight, showed the formation of starch from glucose that had been taken in by the roots. Similar results were not obtained in darkness, perhaps because less glucose was absorbed. Autophytes are found to differ from saprophytes not only quantitatively, as appears from the above, but also more fundamentally. Careful experimentation failed to disclose any power on the part of the roots of green plants to digest starch, a power possessed by holosaprophytes. A chapter is devoted to the consideration of the

[13] LAURENT, J.: Recherches sur la nutrition carbonée des plantes vertes à l'aide de matières organiques. Rev. Gén. Bot. **16**: 14–48; 66–80; 96–128; 155–166; 188–203; 231–242. 1904.

influence of organic substances on growth and form. In general, stem growth is checked in concentrated solutions. While this is doubtless partly due to the increased osmotic pressure, it is evident that chemical factors are also active, since glucose and glycerin solutions of equal concentration give different results. A final chapter deals with the application of his results to agriculture.—HENRY C. COWLES.

KIRKWOOD[14] has published the results of an extended investigation of Cucurbitaceae, chiefly relating to the development of the ovary and the embryo sac structures. The genera included are Fevillea, Melothria, Apodanthera, Bryonopsis, Trichosanthes, Momordica, Luffa, Cucumis, Lagenaria, Benincasa, Citrullus, Cucurbita, Sicyos, Micrampelis, Coccinia, and Cyclanthera, a remarkable list for one investigator in these days to present in a single paper; but the work has been under way since 1898. The mass of details will always be consulted for comparison with similar details in other families, and it is important to have so compact and clear a record. Certain general results, however, should be referred to even in a brief review. As is well known, the position of the family has always been a problem because of its contradictory characters, but it is generally placed now among the higher Sympetalae. It is interesting to note that Kirkwood has discovered that the sixteen genera studied unanimously contradict certain characters of Sympetalae that have been thought to be fundamental. The ovule of this great group is remarkably constant in its single and very prominent integument, its very much reduced nucellus, and its elimination of tapetal tissue (the hypodermal archesporial cell passing over directly into the mother-cell). In all the Cucurbitaceae studied, however, Kirkwood finds the ovules with two integuments, a well-developed nucellus, and tapetal tissue by no means eliminated, but often very extensive. It seems to the reviewer that just as the single character of polypetaly, arbitrarily applied, has detained the Umbelliferae among the Archichlamydeae, so the single character of sympetaly has forced the Cucurbitaceae among the Sympetalae. The synergids are remarkable for their prominence and structure, and the antipodals are ephemeral. Material did not permit a study of the peculiar pollen tubes reported for the family, or of fertilization and the development of the embryo. The endosperm is noteworthy for its extensive growth and nutritive activity, to which the author has given somewhat detailed attention. The general conclusions from the development of the ovary, especially the growth of the variable "placenta" and the origin of the ovules, are used in an interesting way to relate the genera in phylogenetic series.—J. M. C.

FITTING'S[15] preliminary report promises a paper which will be of special interest because he has attempted a solution of several of the most fundamental problems of geotropism. The behavior of orthotropic organs upon a klinostat

[14] KIRKWOOD, JOSEPH EDWARD, The comparative embryology of the Cucurbitaceae. Bull. N. Y. Bot. Garden. **3**: 313–402. *pls. 58–69.* 1904.

[15] FITTING, H., Geotropische Untersuchungen. (Vor. Mit.) Ber. Deutsch. Bot Gesells. **22**: 361–370. 1904.

so arranged that the rotating plant describes a cone whose axis is inclined to the horizontal leads him to announce the following statements. The optimum position for geo-perception is horizontal and equal responses are induced by equal deviations above and below the horizontal. (In a recent paper NEWCOMBE[16] finds that roots and stems do not receive equal stimuli at equal angles above and below the horizontal.) The minimum perception time is extremely brief, less than two-thirds of a second. A proportionality between reaction time and perception time does not exist. Orthotropic organs can be geotropically stimulated even though the rotation be very rapid and uniform. There is a threshold-difference not only for intensity of stimulation but also for duration of stimulation, and for position during stimulation (deviation from horizontal). Intermittent is much less effective than continuous stimulation in the induction of geotropic curvatures. The response is little affected by the duration and number of individual stimulations. The presentation time is never smaller than for continuous stimulation, and is practically the same as for the latter when the ratio of stimulus duration to rest duration is as small as 1:5. The duration of single stimuli is without influence upon reaction time so long as the ratio of rest duration to stimulus duration does not exceed 5:1. Nothing was observed which would support HABERLANDT'S statolith hypothesis.—RAYMOND H. POND.

SPINDLE FORMATION in the pollen mother-cells of *Cassia tomentosa* L. has been studied by HUS,[17] who finds that the cytoplasm of the young pollen mother-cell consists of a network of fibers more or less radially arranged, on and between which large and small granules are found. The meshes adjacent to the nuclear wall become smaller and elongated parallel to that wall. A granular zone appears around the nucleus; and at the same time there appears in the cytoplasm deeply staining rough fibers frequently arranged in conical groups. A felt-like zone, partially or sometimes completely surrounding the nucleus, next appears, and the deeply staining rough fibers of the cytoplasm, now united into cones, establish connection with the fibers of the felt-like zone. The linin threads become parallel with the other fibers and also parallel with the axis of the larger or ascendant cone. As soon as the rough threads of the fibers become smooth, the nucleolar wall breaks down, the linin and the kinoplasmic fibers anastomose and become grouped into bundles. A multipolar spindle is formed, two cones of which, opposite to each other, are more prominent and gradually absorb the smaller cones. The spindle of the second division is more pronouncedly multipolar than that of the first division. HUS concludes that "the spindle formation in *Cassia tomentosa* L. forms a connecting link between the multipolar polyarchal spindle *Anlage* ordinarily met with in dividing mother-cells of pollen, spore, and embryo-sac, and the multipolar diarchal spindle *Anlage* described for vegetative cells."—W. J. G. LAND.

[16] NEWCOMBE, F. C., Limitations of the klinostat as an instrument for scientific research. Science **20**:376–379. 1904.

[17] HUS, HENRI T. A., Spindle formation in the pollen mother-cells of *Cassia tomentosa* L. Proc. Calif. Acad. Sci. III. **2**:329–354. *pls. 30–32.* 1904.

LANG[18] has described in detail the single prothallus that he refers provisionally to Psilotum; otherwise the gametophyte of Psilotaceae is entirely unknown. During his expedition to the Malayan peninsula, LANG found a number of plants of Psilotum growing on the stems of tree ferns, with rhizomes embedded among the adventitious roots covering the stems. In close association with one of these plants the single prothallus referred to was found. A preliminary account of its external form was published in 1901. It is thick cylindrical, about 6^{mm} long and 4.5^{mm} in diameter at the broad upper end. It shows the usual differentiation of the subterranean gametophytes of Lycopodium into vegetative region below and sexual region above. The latter appears as a thick overhanging margin in which numerous antheridia occur. The sexual region does not contain chlorophyll, as in the *Lycopodium cernuum* type, the gametophyte evidently being entirely saprophytic. The vegetative region exhibits considerable histological differentiation, an endophytic fungus occupying a peripheral zone, and the central mass of tissue being entirely free from it. Some very interesting details in reference to the fungus are given, especially the occurrence of some remarkable multinucleate "vesicles" borne upon it. If this gametophyte is that of Psilotum, the genus is closely related to the homosporous Lycopodiales; if it is not, it is certainly the gametophyte of some Lycopodium.—J. M. C.

IN A RECENT number of *Science* MORGAN[19] attempts an analysis of the phenomena of organic "polarity." He opposes the "formative stuff" hypothesis of SACHS and others, or rather that feature of it which calls for the migration of specific formative material, and arrays considerable evidence against it. MORGAN's conception is that while the material which gives rise to new parts is totipotent, it is not homogeneous, so that it is different at different levels of the body, this difference being graded from one end of the organism to the other. This accounts for the gradation in the facility with which new parts are formed from one end to the other. Morgan also recognizes an organizing principle, which he calls the property of "formative organization," "which acts on the new and old parts as a whole and determines the relative arrangement and proportions of the new organs."

In regard to "polarity" in plants Morgan maintains that these same principles hold. Assuming that there is a gradation from the distal to the proximal end of say, a mullen stem, in the size and vigor of the buds, the greater ability to produce shoots at the distal end is due merely to the fact that these buds are more vigorous and mature. The suggestion is made that the opposite may be true of the roots.—W. B. MCCALLUM.

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[18] LANG, WILLIAM H., On a prothallus provisionally referred to Psilotum. Ann. Botany **18**: 571–577. *pl. 37*. 1904.

[19] MORGAN, T. H., An analysis of the phenomena of organic "polarity." Science **20**: 712–748. 1904.

IN A COMMUNICATION to the Royal Society December 1, SCOTT[20] described a new type of strobilus belonging to the Sphenophyllales. The close affinity to Sphenophyllum is shown by the anatomy of the axis, which has the solid triarch wood characteristic of that genus, and by the fact that the whorled sporophylls are divided into dorsal and ventral lobes, as in all other known fructifications of this class. But, whereas, in all the forms hitherto described the lower or dorsal lobes are sterile, forming a system of protective bracts, while the ventral lobes alone bear the sporangia; in the new cone, dorsal and ventral lobes are alike fertile, and no sterile bracts are differentiated. Each lobe of the sporophyll divided palmately into several segments, the sporangiophores, each of which consisted of a slender pedicel, terminating in a large peltate lamina, on which two pendulous sporangia were borne. The wall of the sporangium has a rather complex structure, the most interesting feature in which is the well-defined small-celled stomium, marking the line of longitudinal dehiscence. The spores, so far as observed, are all of one kind; they are ellipsoidal in form, with longitudinal crests or ridges; their dimensions are 90–96 μ in length by 65–710 μ in width.—J. M. C.

THE COMMON *Ithyphallus impudicus*, generally considered to be a saprophyte only, has been found to be the cause of a destructive root rot of the vine in Hungary. According to the account given by ISTVÁNFFI[21] the subterranean part of the stem is entwined by a network of the characteristic cord-like strands of mycelium of this fungus. From these, branches are sent into the interior of the stem. Small roots are totally destroyed by strands which penetrate them lengthwise, destroying all the tissues and leaving only the thin decaying cortex. In the older roots the cortex and phloem are totally destroyed, leaving only a mass of débris. The wood cylinder is last attacked, but this also is finally destroyed, leaving only scattered remnants of the vessels. Destruction of the immature fruit-bodies and watering the exposed roots with fungicides is recommended as a means of prevention.

The same paper also contains an account of a mite, *Coepophagus echinopus*, which lives within and destroys the tissues of the roots of the vine. Not infrequently vines are attacked by both pests at the same time.—H. HASSELBRING.

SVEDELIUS[22] has published an account of *Enalus acoroides*, one of the marine Hydrocharitaceae growing on the coast of Ceylon; the subtitle being "A contribution to the ecology of the hydrophilous plants." The pollen grains are very large (about 170 μ in diameter) and heavier than sea water, owing to the presence

[20] SCOTT, D. H., On the structure and affinities of fossil plants from the Paleozoic rocks.—V. On a new type of sphenophyllaceous cone (*Sphenophyllum fertile*) from the Lower Coal-measures. Read December 1, 1904.

[21] ISTVÁNFFI, GY DE, Deux nouveaux ravageurs de la vigne en Hongrie (l'*Ithyphallus impudicus* et le *Coepophagus echinopus*). Ann. Inst. Cent. Ampélologique Roy. Hongrois **3**:1–55. *pls. 1–3. figs. 15.* 1904.

[22] SVEDELIUS, N., On the life history of *Enalus acoroides*. Ann. Bot. Gard. Peradeniya **2**:267–297. *pl. 24.* 1904.

of numerous starch grains. The wing-like leaves of the ovulate spathe aid in keeping the flower in a horizontal position, and the petals are specially adapted to catch the floating staminate flowers. The exposure of the ovulate flowers and the loosening of the staminate flowers occur only during low water. During high water the ovulate flowers are vertical; and the heavy pollen grains can scarcely avoid sinking down upon the erected stigmas. The pollination of Enalus, therefore, is both at the surface of the water and beneath it. The development of the embryo is of the ordinary Alisma-type, with a very large basal suspensor cell. At maturity the testa is an easily loosened cap around the embryo, the latter escaping entire and developing immediately.—J. M. C.

LOCK[23] has been investigating the rate of growth of the giant bamboo (*Dendrocalamus giganteus*) in Ceylon. The stems show a gradually increasing rate of growth up to 5^m; then a nearly constant rate up to 15^m; then a slowly diminishing rate to the final height of 30^m or more. The average daily rate at a height of 1^m is 10^{cm} per day; at 5–15^m, 30^{cm}; and at 20–25^m, 15^{cm}. The greatest growth recorded in 24 hours was 46^{cm}. The daily rate of growth is much increased by rainfall, the effect being greater the greater the height of the stem. The greatest change observed in rate of growth in two successive days was 50 per cent. of the average rate. Growth is almost always more rapid at night; the average hourly growth at heights of 3–12^m between 7:00 A.M. and 5:00 P.M. being 6^{mm}, and between 5:00 P.M. and 7:00 A.M. 16^{mm}; the maximum rate being reached soon after dark. The curve of growth by day follows very closely that of the percentage moisture of the air.—J. M. C.

THE SECOND section of DAVIS'S[24] *Studies on the plant cell* is entitled, "Activities of the plant cell." The activities described are (1) vegetative activities, and (2) cell division. Cell division is treated under the subheads (*a*) the events of nuclear division and (*b*) the segmentation of the protoplasm. The account of mitosis in the thallophytes is particularly clear. The origin of the spindle is discussed in detail and considerable attention is paid to the centrosome problem. The view is expressed that all divisions of chromosomes are longitudinal. The evidence in favor of regarding the chromosome as a permanent organ of the cell is regarded as not yet sufficient. In dealing with the segmentation of the protoplasm, the author gives a valuable summary of recent work in this field. —CHARLES J. CHAMBERLAIN.

BURNS[25] concludes that in *Proserpinaca palustris* L. the water-environment is not the cause of the division of the leaf. He considers that the plant has two

[23] LOCK, R. H., On the growth of giant bamboos, with special reference to the relation between conditions of moisture and the rate of growth. Annals Bot. Gard. Peradeniya **2**:211–266. *pls. 21–23.* 1904.

[24] DAVIS, B. M., Studies on the plant cell. Amer. Naturalist **38**:431–469. *figs. 4–8.* 1904.

[25] BURNS, G. P., Heterophylly in *Proserpinaca palustris* L. Ann. Botany **18**: 579–605. *pl. 38.* 1904.

types of leaves, an adult and a juvenile type, the latter being the divided form. Under good vegetative conditions the former is produced, while under poor vegetative conditions the juvenile form is developed. A reversion from the adult to the juvenile form follows a change from a favorable to an unfavorable vegetative condition.—W. B. McCALLUM.

LLOYD[26] calls attention to the parallelism between the results of his studies of the pollen tubes in the Rubiaceae and those of LONGO in the Cucurbitaceae. Each of these investigators has found that the pollen tubes vary greatly in behavior, even in closely related genera or species. They seem to have come independently to the same conclusion; that is, that endotropism and ectotropism are not distinct from one another; both regard the behavior of the pollen tube as a physiological character.—R. B. WYLIE.

WRIGHT[27] has published an extended account of the gross morphology, anatomy, and taxonomy of Diospyros as represented in Ceylon. The family is of such interest among dicotyledons that so extensive a study of living material is welcome. In the taxonomic portion of the paper twenty species are recognized and described in great detail.—J. M. C.

STUDENTS of plant-breeding will be interested in the results obtained by LOCK[28] in conducting a somewhat extensive series of experiments in Ceylon. In his first paper the details of the experiments indicate in the main a confirmation of MENDEL'S law.—J. M. C.

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[26] LLOYD, F. E., The pollen tube in the Cucurbitaceae and in the Rubiaceae. Torreya **4**:86–91. 1904.

[27] WRIGHT, HERBERT, The genus Diospyros in Ceylon: its morphology, anatomy, and taxonomy. Annals Bot. Gard. Peradeniya **2**:1–106, 133–210. *pls. 1–20.* 1904.

[28] Lock, R. H., Studies in plant-breeding in the tropics. I. Ann. Bot. Gard. Peradeniya **2**:299–356. 1904.

NEWS.

PROFESSOR H. MARSHALL WARD has been elected president of the Cambridge Philosophical Society.

DR. J. F. GARBER (University of Chicago) has been appointed instructor in botany in the Yeatman High School of St. Louis.

MR. LUTHER BURBANK, so well known for his experiments in plant-breeding, has been appointed a special lecturer at Stanford University.

DR. J. C. ARTHUR has been appointed by the Botanical Society of America as its delegate to the International Botanical Congress at Vienna.

DR. MARIE C. STOPES (Munich) has been appointed assistant lecturer and demonstrator in botany in the University of Manchester, England.

WELLESLEY COLLEGE has received $7200 from the ROBERT CHARLES BILLINGS fund, the income of which is to be applied to the needs of the department of botany.

WILLIAM R. MAXON, of the U. S. National Herbarium, left Washington December 12 for Guatemala, to be gone until May. Primarily he is to be engaged in cotton investigation.

PROFESSOR N. ONO, of the University of Tokyo, has been visiting the botanical laboratories of the United States on his way to the University of Leipzig for research in plant physiology.

C. R. BARNES, H. C. COWLES, and C. L. SHEAR were appointed delegates from the American Association for the Advancement of Science to the International Botanical Congress at Vienna.

MR. FRANCIS DARWIN who, upon his removal to London some months ago, retired from his position as Reader in Botany in Cambridge University, has been succeeded by Mr. F. F. BLACKMAN.

DR. R. S. WOODWARD, dean of the faculty of pure science in Columbia University, was elected president of the Carnegie Institution at the meeting of the trustees held at Washington, December 13.

THE ROYAL SOCIETY of London has awarded the Darwin medal of 1904 to Mr. William Bateson, "for his contributions to the theory of organic evolution by his researches on variation and heredity."

A CONTROLLING INTEREST in *The Plant World* has been purchased by Professor F. E. LLOYD, of the Teachers College, Columbia University, the journal passing under his editorial management at the beginning of the new year.

MR. R. P. GREGORY, demonstrator of botany at Cambridge University, has been awarded the Walsingham medal of the university for 1904, his thesis being "The reduction division in plants and its significance in the physiology of heredity."

THE Botanical Society of America elected as officers for the ensuing year: president, R. A. HARPER; vice-president, E. A. BURT; secretary, D. T. MACDOUGAL; treasurer, ARTHUR HOLLICK; councillors, L. M. UNDERWOOD, WM. TRELEASE.

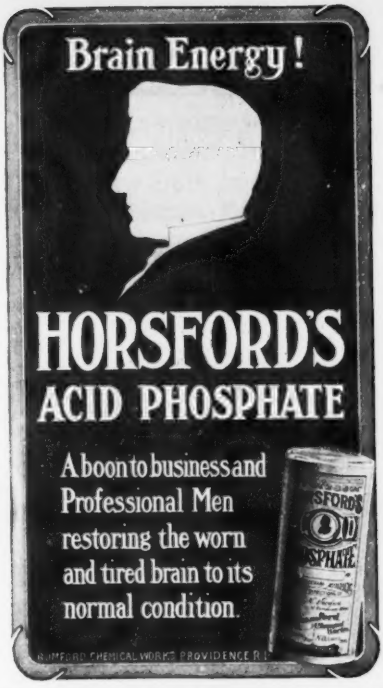
DR. BURTON E. LIVINGSTON will sever his connection with the University of Chicago at the close of the winter quarter, having been appointed to the staff of the Bureau of Soils of the U. S. Department of Agriculture. He will take up his new duties at Washington on April 1.

PROFESSOR HENRY S. GRAVES, director of the Yale School of Forestry, has been commissioned by the Bureau of Forestry to do "inspection work" in the Philippines. During the winter his courses will be conducted by Professor B. E. FERNOW, formerly director of the Cornell School of Forestry.

BEGINNING with this year and volume 18, the *Beihefte zum Botanisches Centralblatt* which has attained an enviable reputation for the prompt publication of original papers of a high grade, will be issued under the same editors, Drs. UHLWORM and KOHL, by a new publisher, GEORGE THIEME, of Leipzig. Hereafter the journal will be published in two sections, the first to cover anatomy, histology, morphology, and physiology; the second being restricted to taxonomy, phytogeography, and like topics. The price of each section is to be *M* 16.

ALBERT GAUDRY, the eminent paleontologist, has headed a subscription for the erection of a monument to the memory of BERNARD RENAULT, whose untimely death this fall brought to a close those remarkable researches which have so greatly enriched the science of paleobotany during the past thirty-six years. It is proposed to erect this monument at Autun, France, RENAULT'S native place and the scene of most of his labors. Subscriptions may be sent to M. BERTHIER, secrétaire de la Société d' histoire naturelle, 2 rue de l' Arbalète, Autun, France.

THE THREE botanical societies, Botanical Society of America, Society for Plant Morphology and Physiology, and American Mycological Society, through committees of conference, have agreed upon certain general principles, upon the basis of which they will fuse into one national society under the name, The Botanical Society of America. For some years the names of all the societies will appear upon official publications until the union becomes thoroughly known. There are to be two classes of membership, members and associates, the distinction being based upon published work. The fees are to be $5 per year. Grants for research are to be made from the income. Meetings are to be annual, with no permanently organized sections, but free opportunity for local meetings or temporary sections in charge of committees. A joint committee has been formed to prepare a constitution for the united societies, which shall embody the principles agreed to, and to complete the reorganization, which is confidently expected to promote research and good fellowship among American botanists.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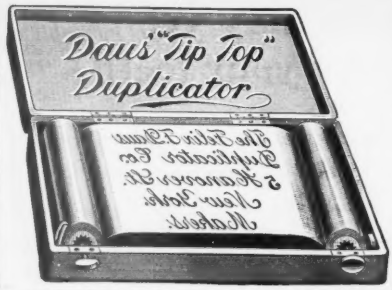

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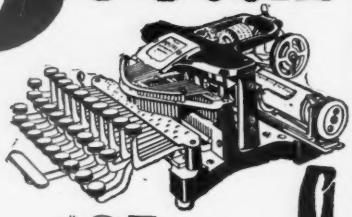

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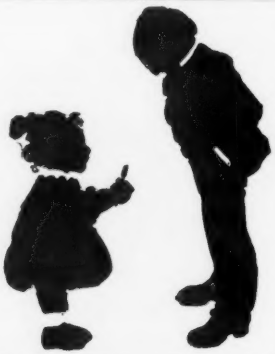

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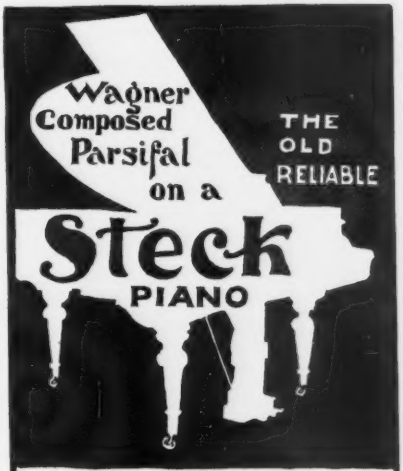
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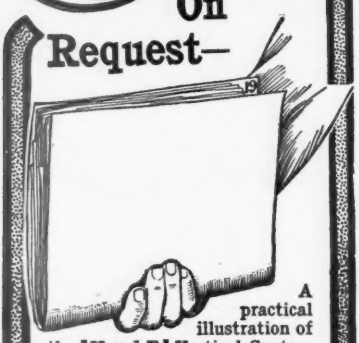
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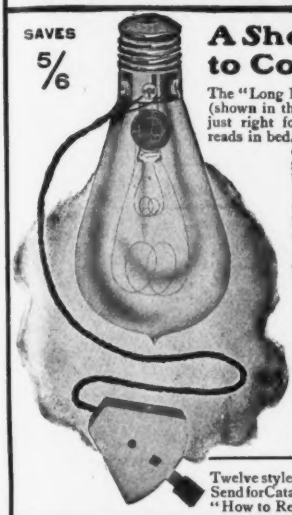

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